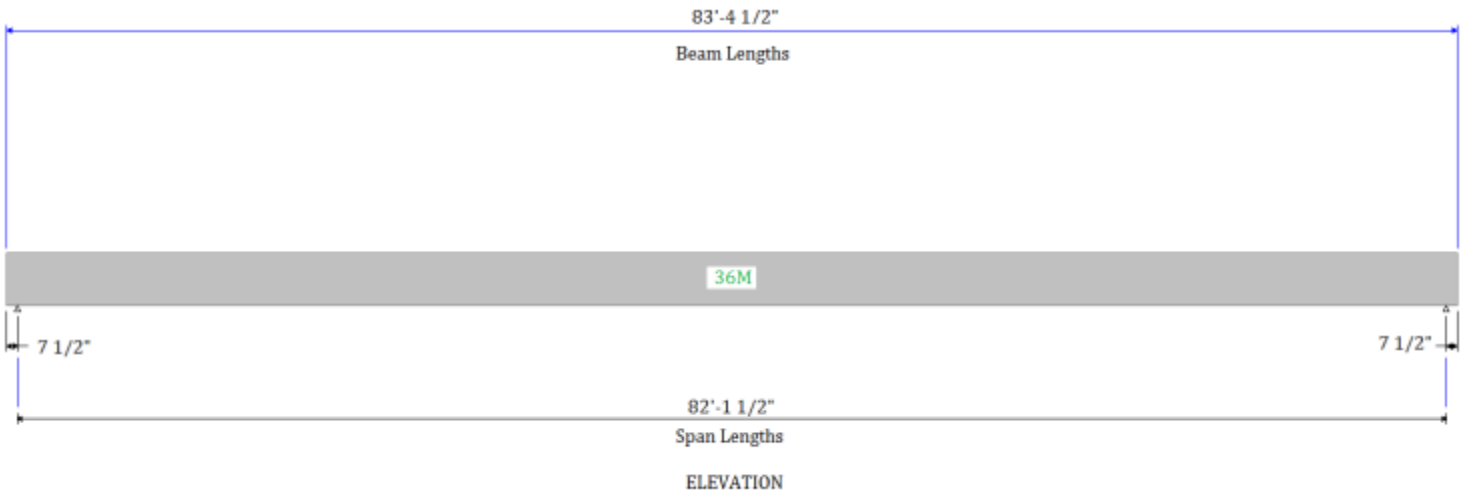
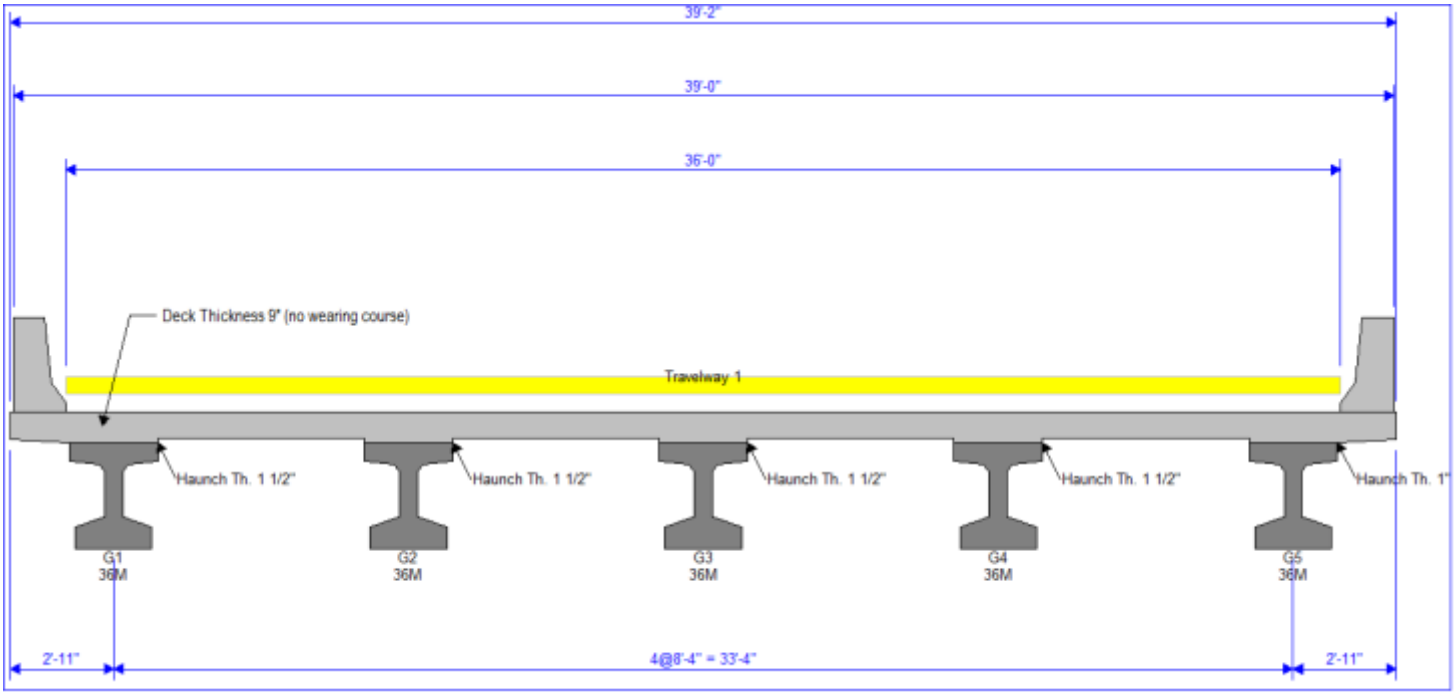
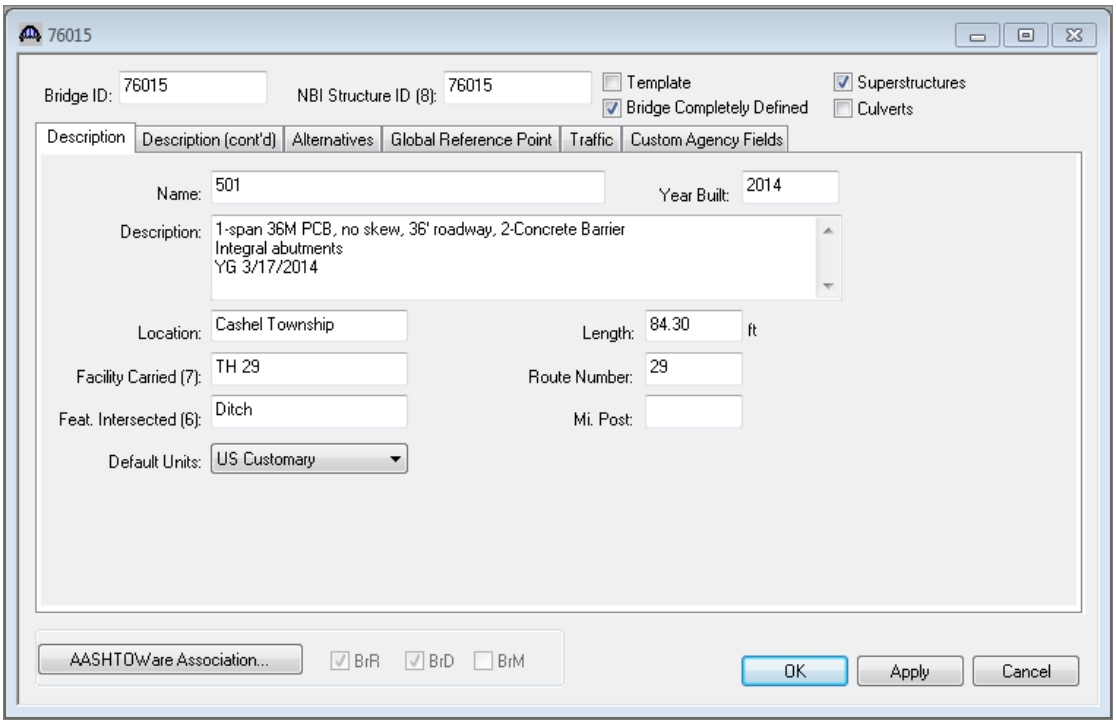
AASHTOWare BrR - SIMPLE SPAN PRESTRESSED I BEAM EXAMPLE - BR 76015



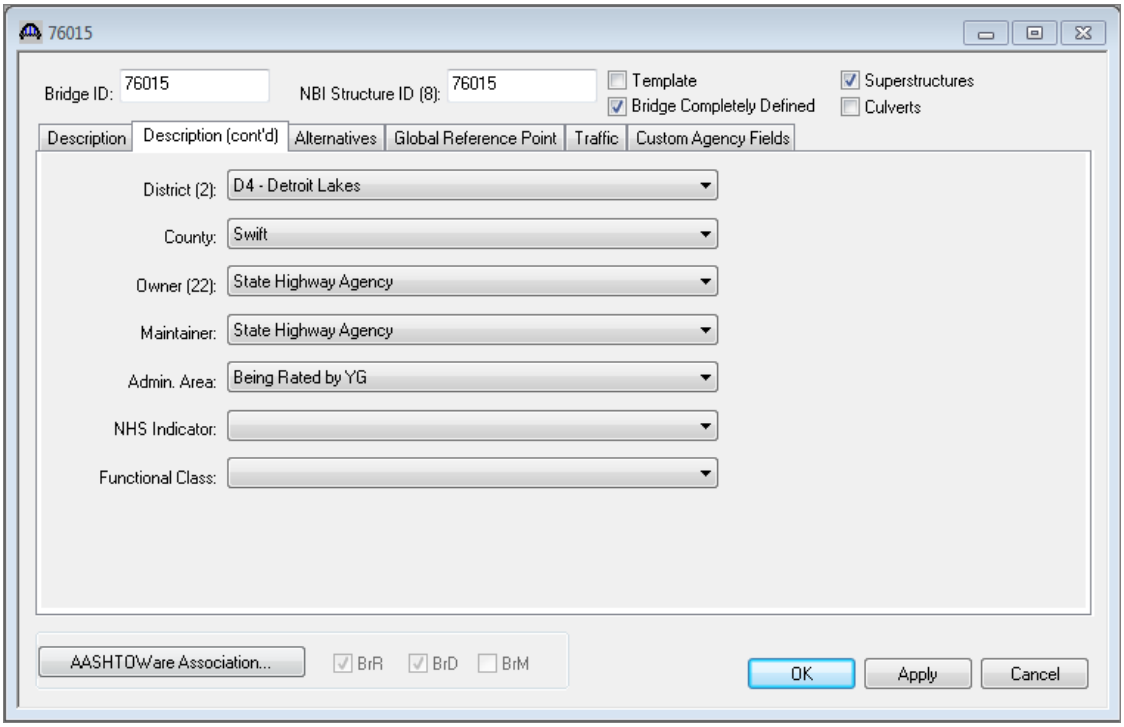


PS1 - Simple Span Prestressed I Beam Example (BrR 6.7.1)

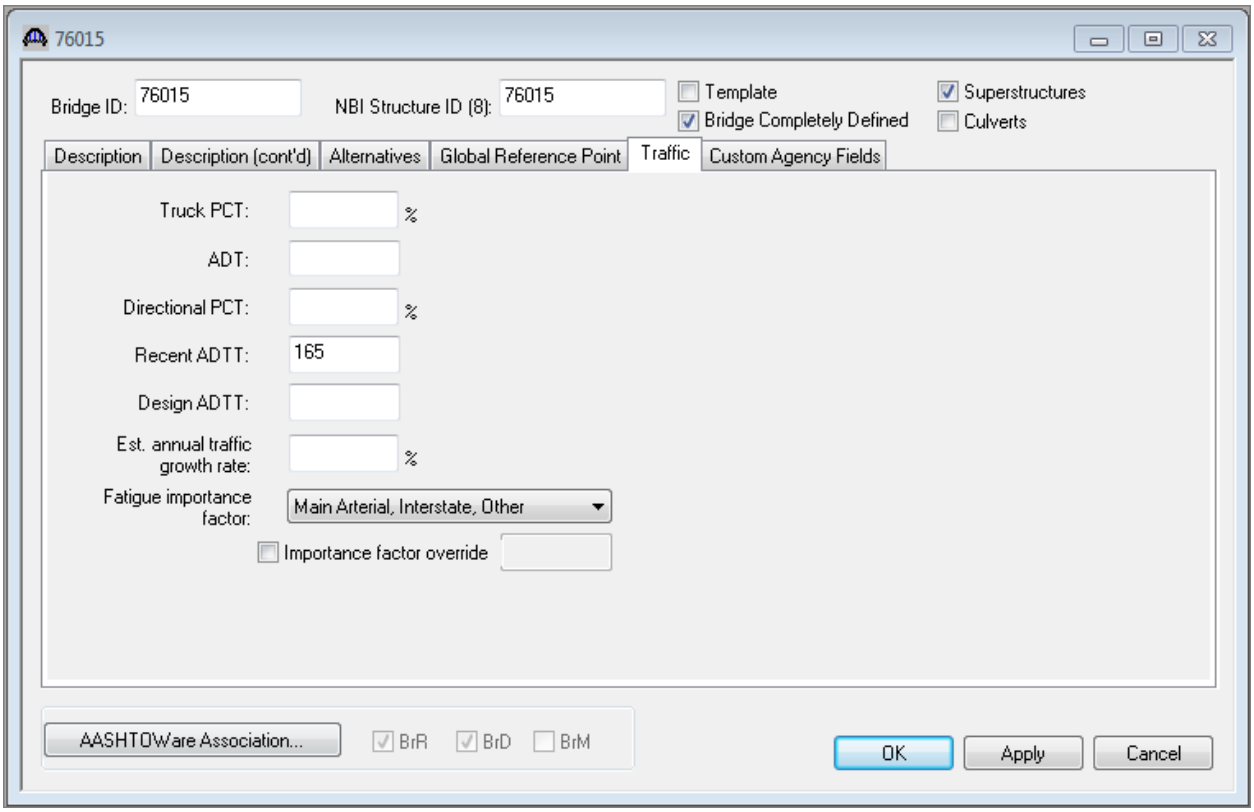
1. From the Bridge Explorer create a new bridge and enter the following description data:
    a. Bridge ID – Enter Bridge number (usually 5 digits). For bridges with only 3 or 4 digits, enter space(s) then enter the bridge number, e.g., __123, _1234
    b. NBI Structure ID – Same as Bridge ID
    c. Bridge Completely Define – Check this box to indicate whether or not the bridge superstructure (members and spans) is completely defined in this BrR file.
    d. Name – Enter the three digit bridge type. (see Bridge LRFD Design Manual, Appendix 2-A). If there is more than one type in the bridge, enter the type of the main span (or lowest rated ?) and add suffix, m (for multiple).
    e. Year Built – Year of construction
    f. Description – select those that apply from list below, add others if needed
        - This Bridge was copied from its' twin, Br xxxxx
        - Twin to Br xxxxx
        - Number of spans
        - Other bridge types if multiple types in one bridge
        - Note if different ratings apply to each side of bridge or direction of traffic or if bridge has one way traffic
        - Flare or curve, note if present
        - Skew angle
        - Describe dead load distribution: Sidewalks, medians, rails, etc.
        - Describe in detail if for any reason the computer model deviates from the plan
        - Does / does not have end blocks, (For prestressed beam bridges)
        - Replaces Bridge xxxx
        - Initials of person rating and date completed
    g. Location – City or Township name
    h. Length – XXXX feet
    i. Facility Carried – Facility carried over the bridge. Use the highway abbreviation without periods. If the bridge carries one way traffic, add this as a suffix. Examples: I 94, I 35 SB, US 12, US 2 WB, MN 36, CSAH 44, CR 88. If no highway number exists, use the street name/number, etc.
    j. Route number - Often the same as Facility carried. If a minor road crosses over a major highway, enter the major highway number. May be a second highway no. over/under. Omit Prefixes (I, US, MN, CSAH, etc.)
    k. Feature intersected - Highway, river, stream or feature under the bridge.
    l. Mile post – Leave blank
    m. Units – English preferred



2. Enter the following description (cont'd)…
    a. District – Select from pull-down menu
    b. County – Select from pull-down menu
    c. Owner – Select from pull-down menu
    d. Maintainer – Select from pull-down menu (usually the same as owner)
    e. Administrative Area – Select from pull down menu
    f. NHS Indicator – Leave blank
    g. Functional Class – Leave blank

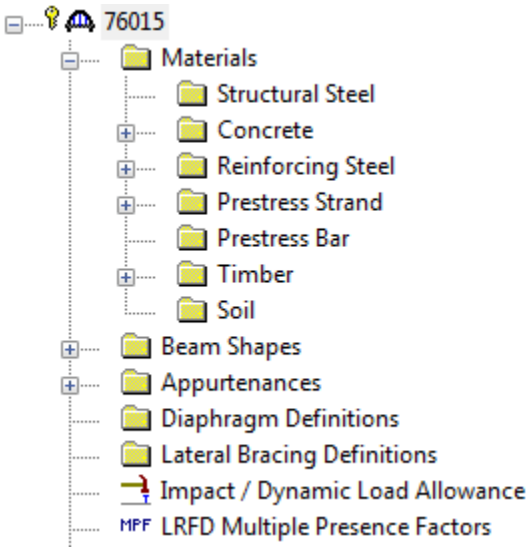


3. Enter the following Traffic information:
    a. Recent ADTT - Enter the current truck traffic volume. This is called HCADT on the MnDOT Structure Inventory Report. If the HCADT is blank on the Inventory Report, use 12 % of the ADT.

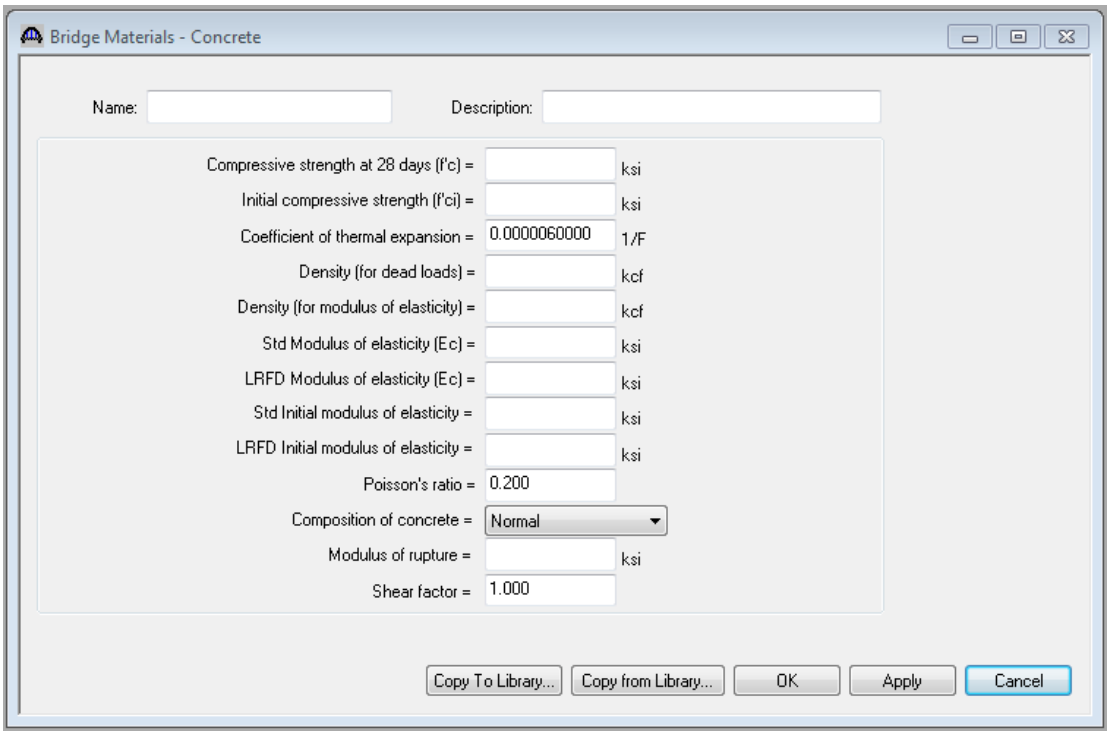


Close the window by clicking OK. This saves the data to memory and closes the window.

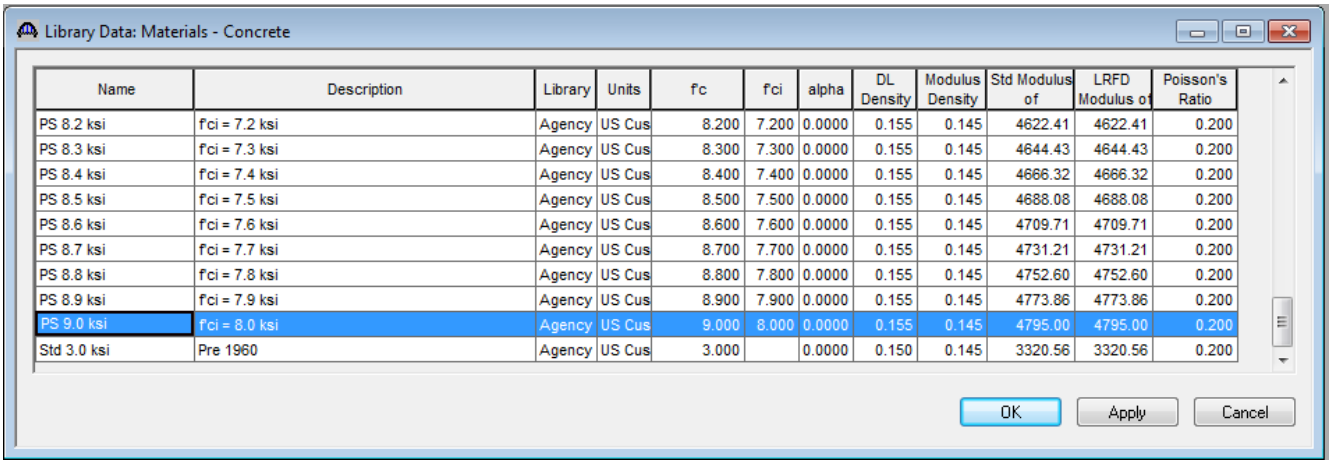
4. To enter the materials to be used by members of the bridge, click on the ⊞ to expand the tree for Materials. The tree with the expanded Materials branch is shown below:



    a. To add a new concrete material for the beam, click on Concrete in the tree and select File/New from the menu (or double click on Concrete). The window shown below will open.



b. Add the concrete material "PS 9.0 ksi" by copying the closest concrete material properties from the Library and modifying the values to match the concrete properties of the beam. See window below.



Note: AASHTOWare BrR only computes modulus of elasticity using AASHTO LRFD Equation 5.4.2.4-1. For f'c > 6ksi, MnDOT uses ACI 363 equation.

MnDOT Design Policy Item:

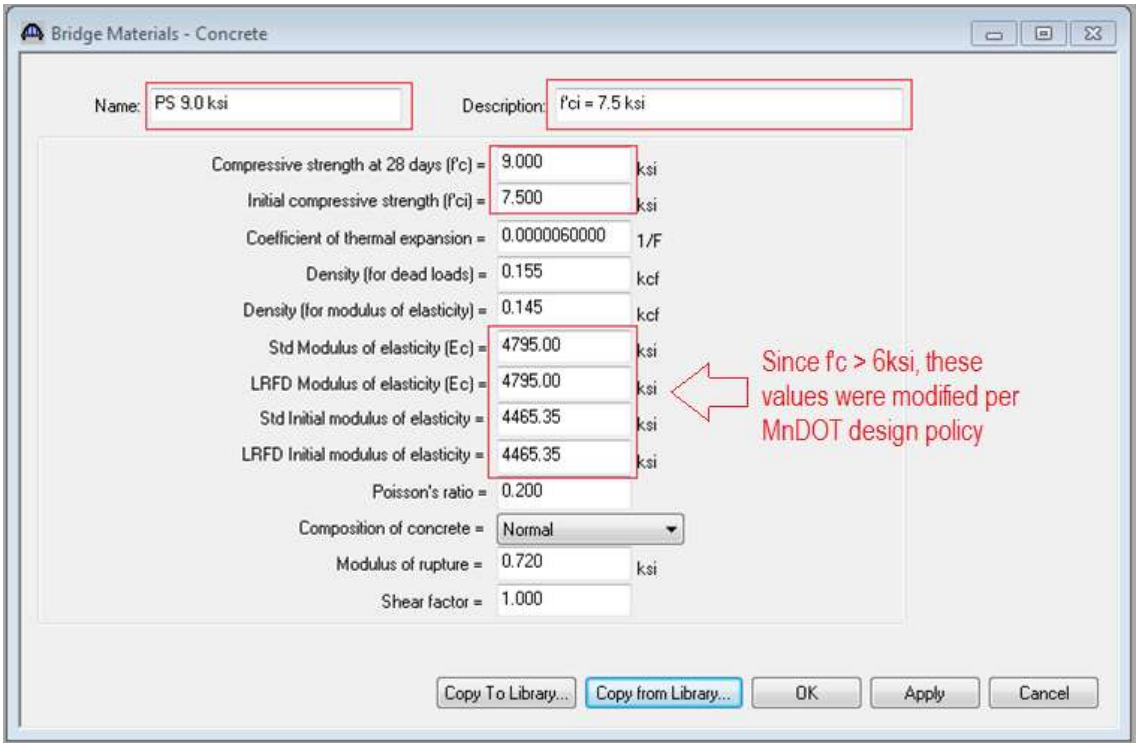
For pretensioned beams (M, MN, MW, and RB) fabricated with highstrength concrete (greater than 6.0 ksi), compute the modulus of elasticity with the ACI 363 equation below:

$$E_c = 1265 * \sqrt{f'_c} + 1000 \quad (where\ f'_c\ and\ E_c\ are\ in\ ksi)$$

For all other pretensioned and post-tensioned elements, compute the modulus of elasticity using AASHTO LRFD Equation 5.4.2.4-1, with K_1 = 1 and w_c = 0.150 kcf.

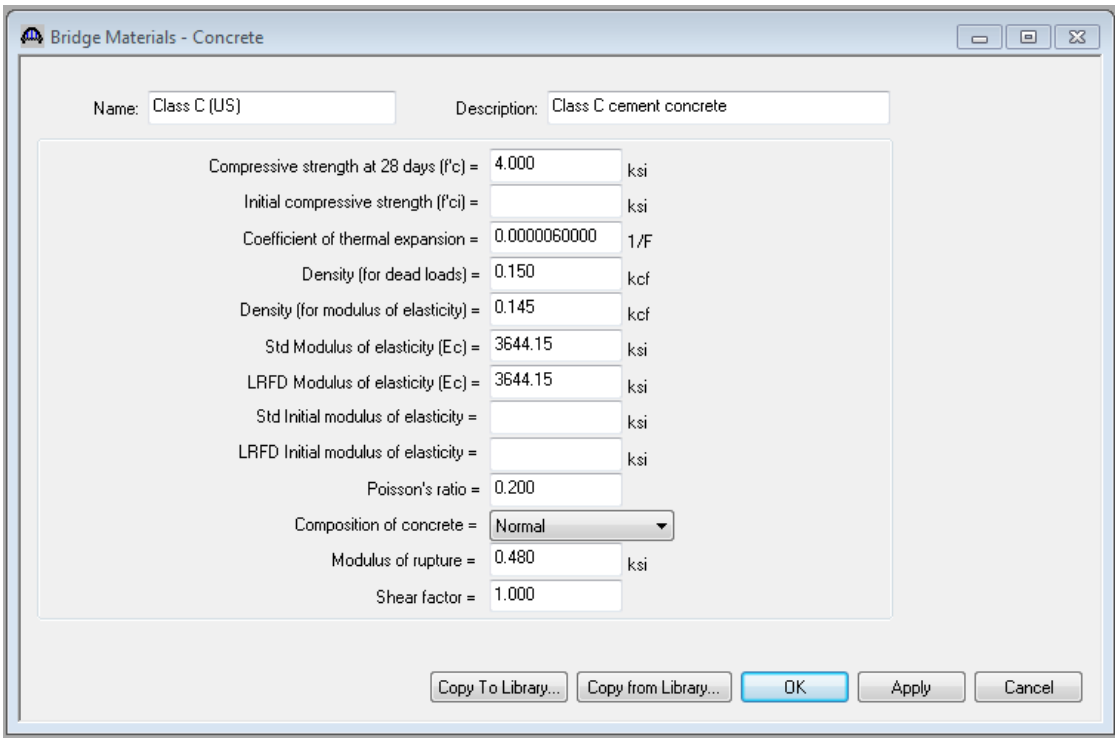
$$E_c = 33{,}000 * K_1 * {w_c}^{1.5} * \sqrt{f'_c}$$

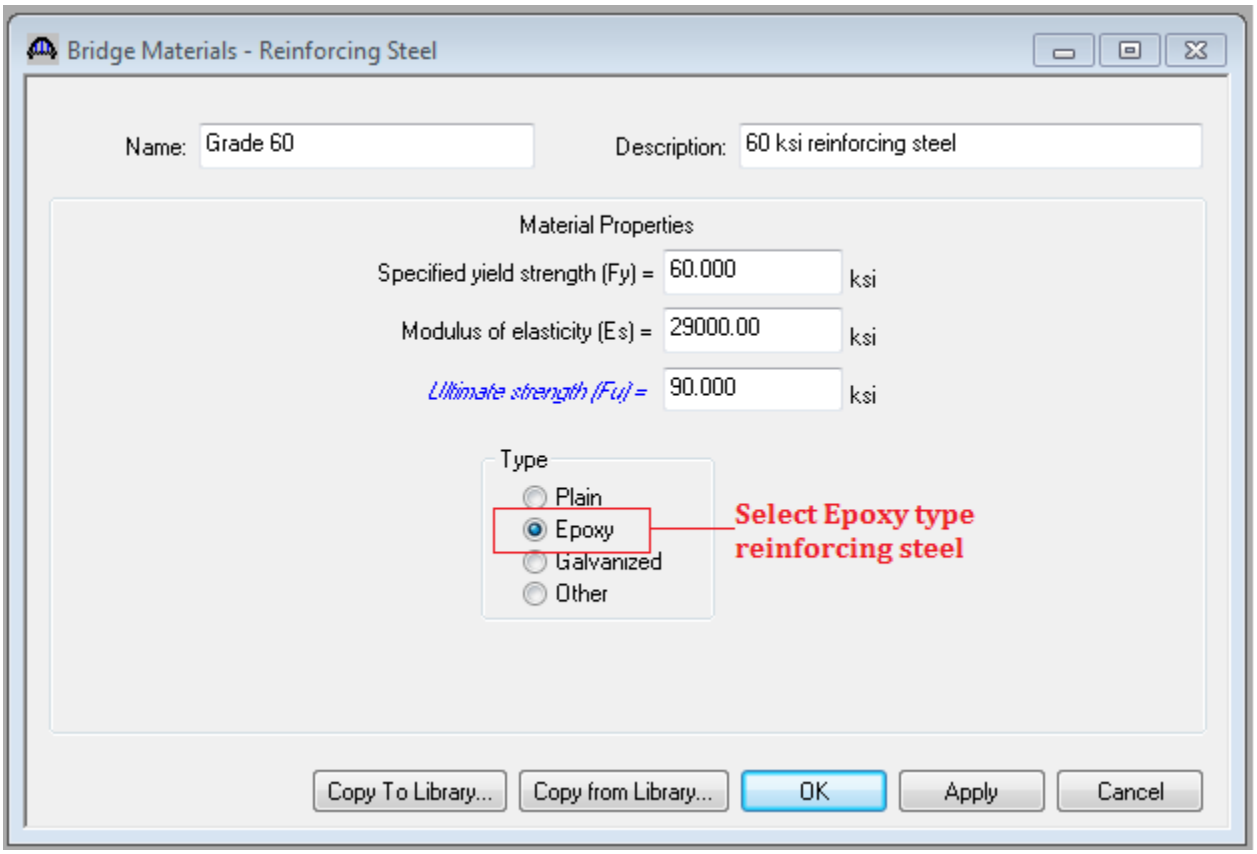
c. Enter appropriate name and description and modify the concrete section property values. See window below:

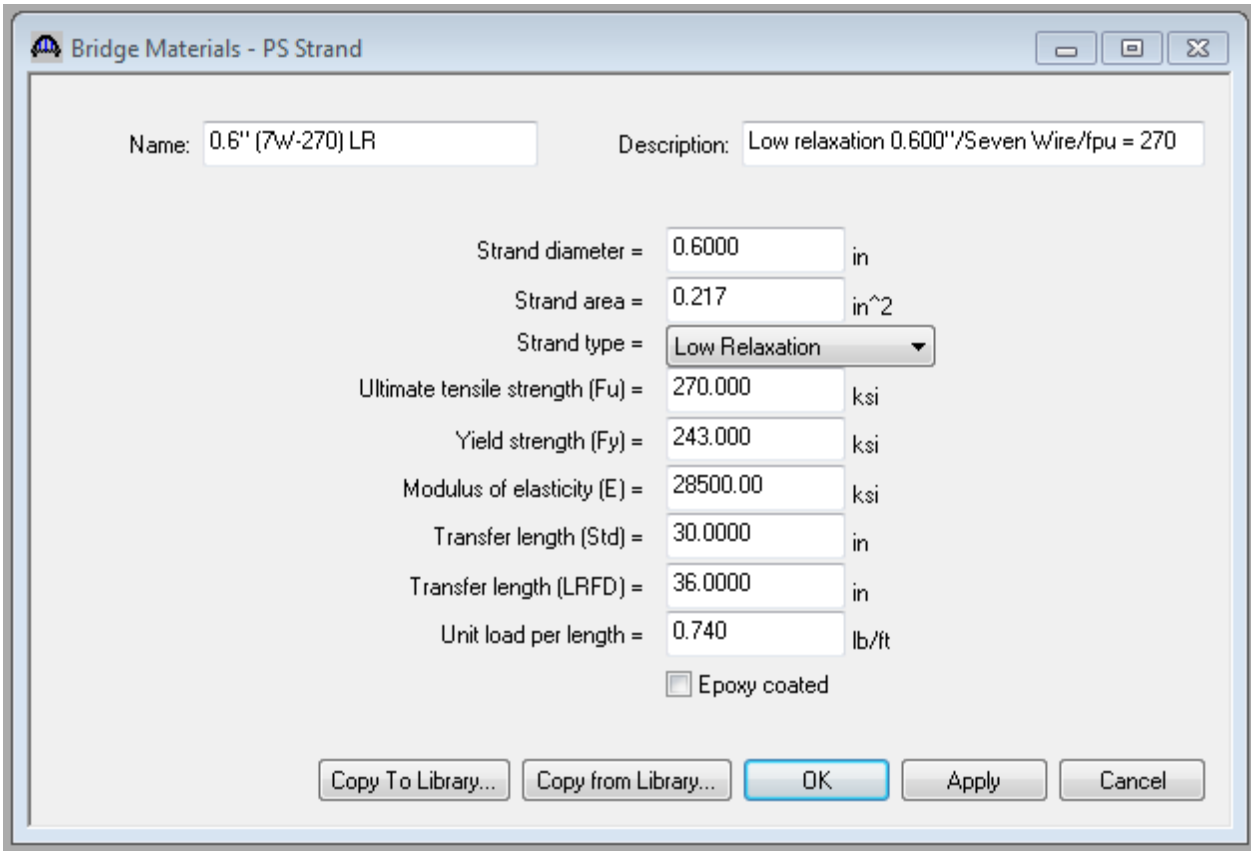


Click OK to save the data to memory and close the window.

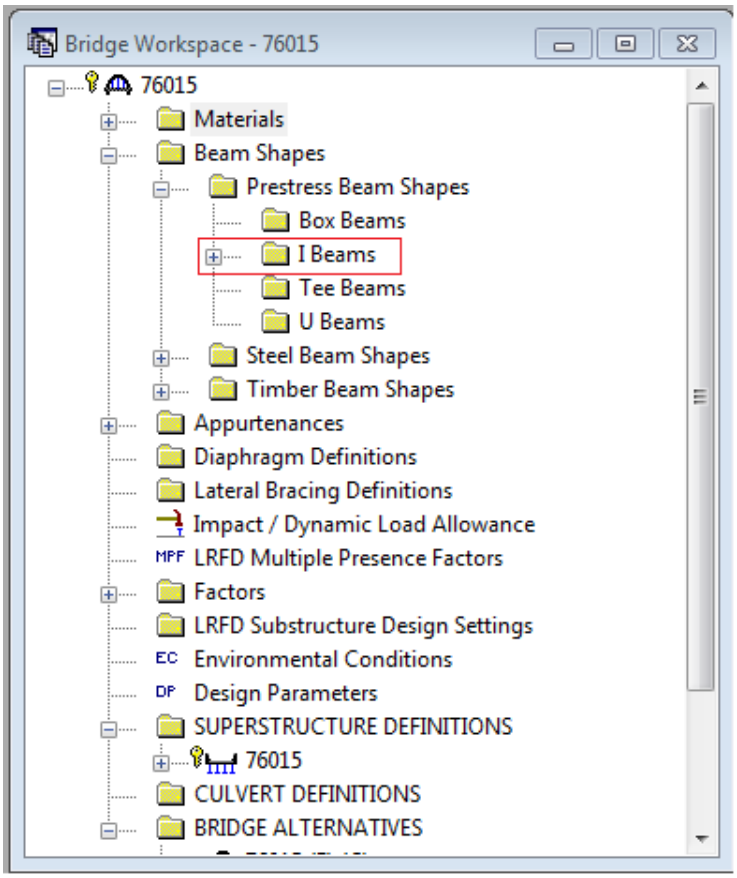
d. Add a concrete material for the deck, reinforcement material and prestress strand using the same techniques by copying from the library. Verify values for accuracy. The windows will look like shown below:



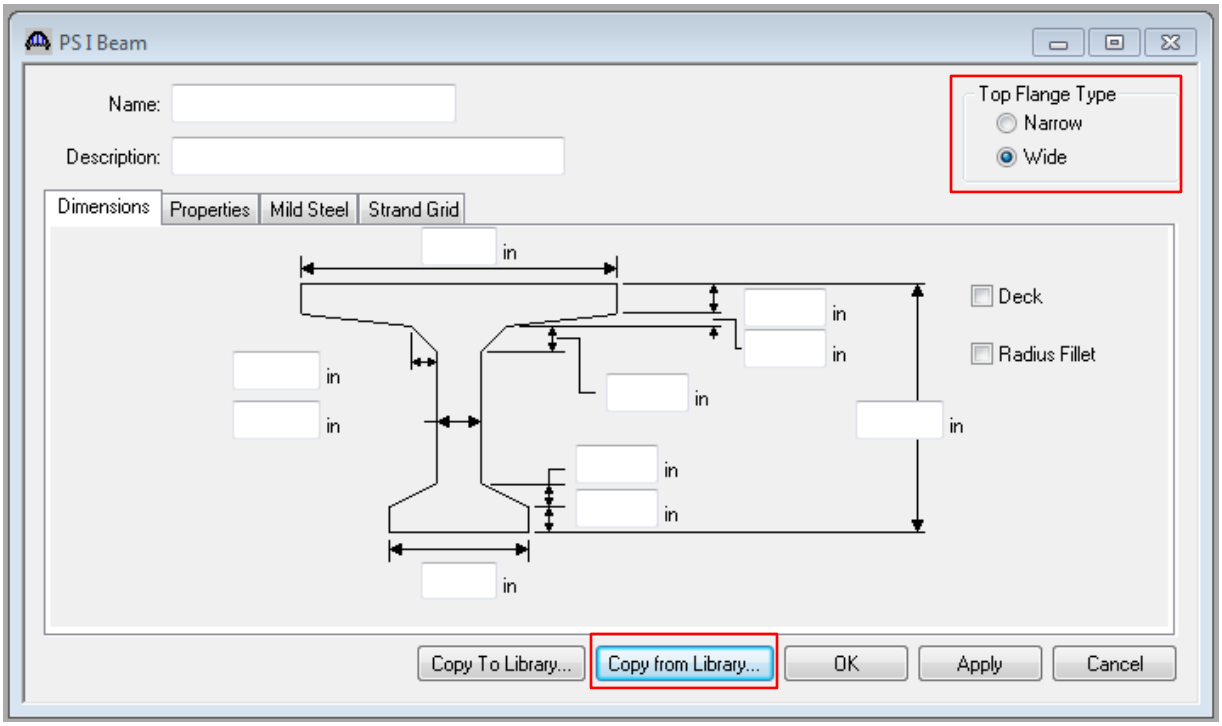




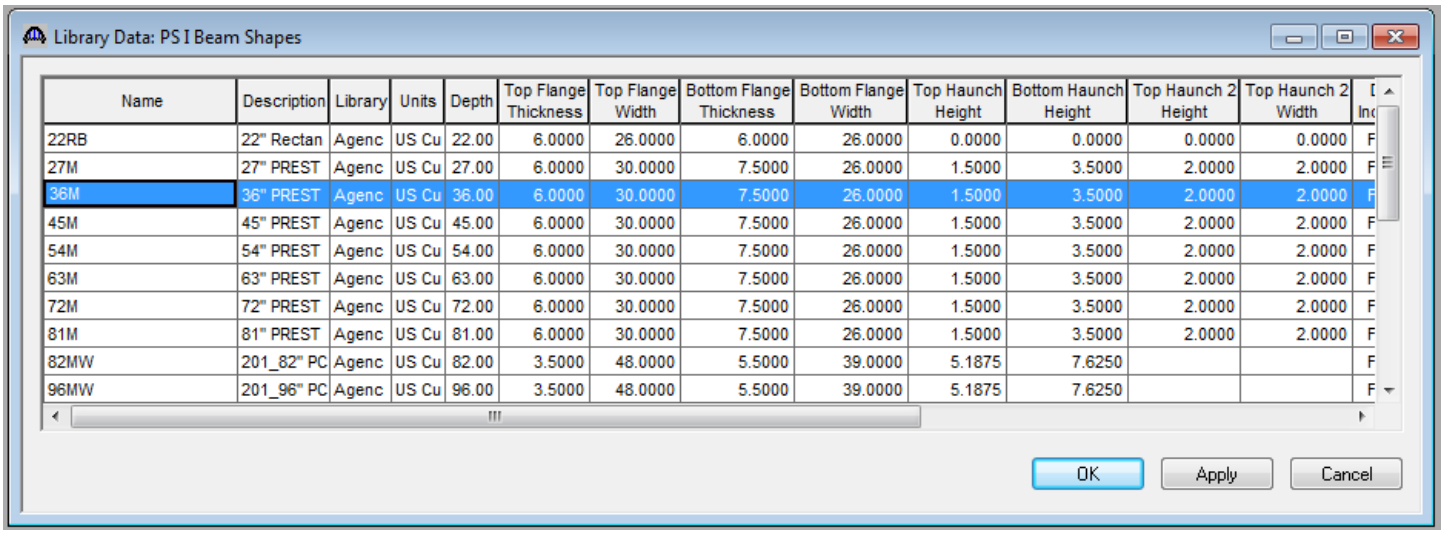
5. To enter a prestress beam shape to be used in this bridge, expand the tree labeled Beam Shapes as shown below:



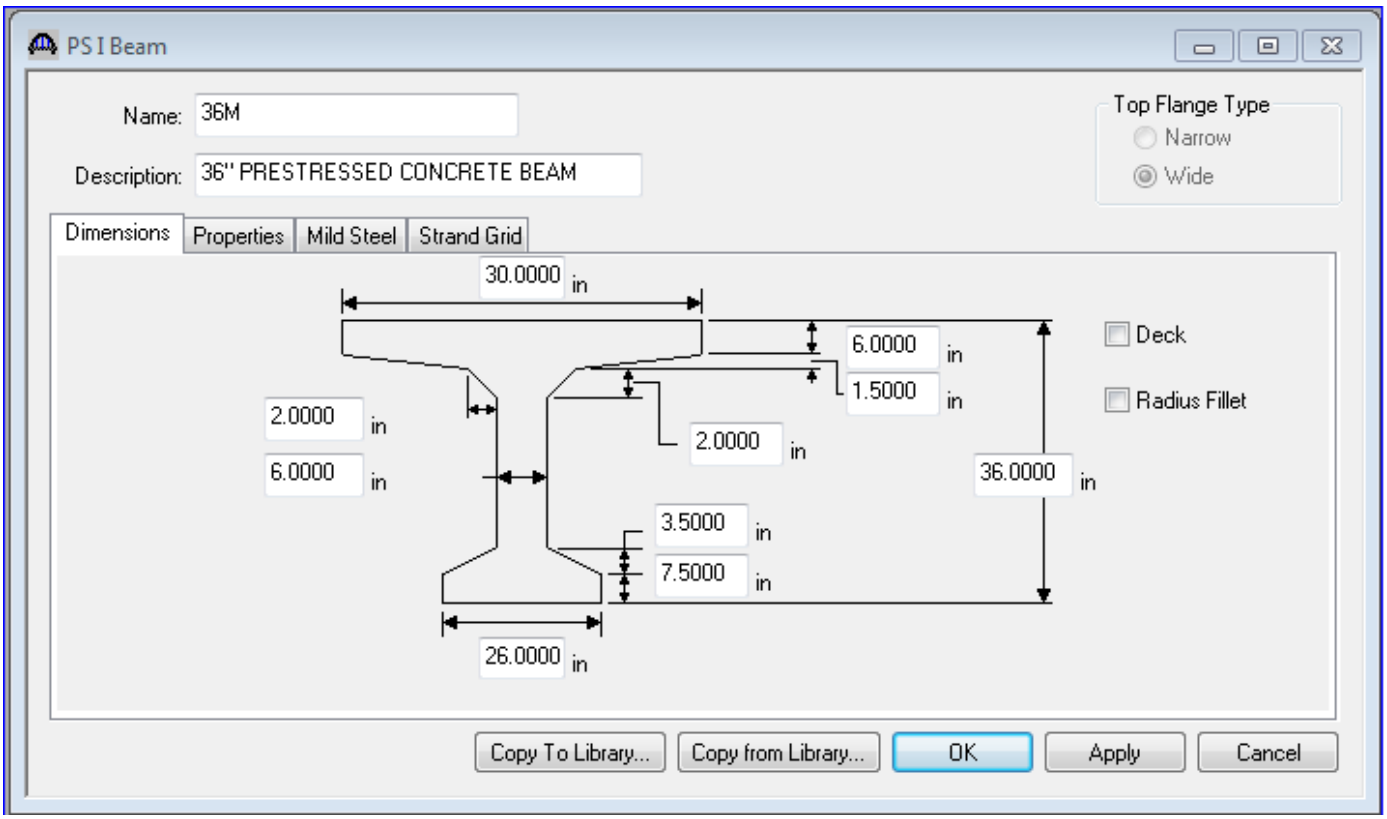
a. Click on I Beams in the tree and select File/New from the menu (or double click on I Beams in the tree). The window shown below will open.



b. Select the Top Flange Type as “Wide” and click on the copy from Library button. Select 36M and click OK.

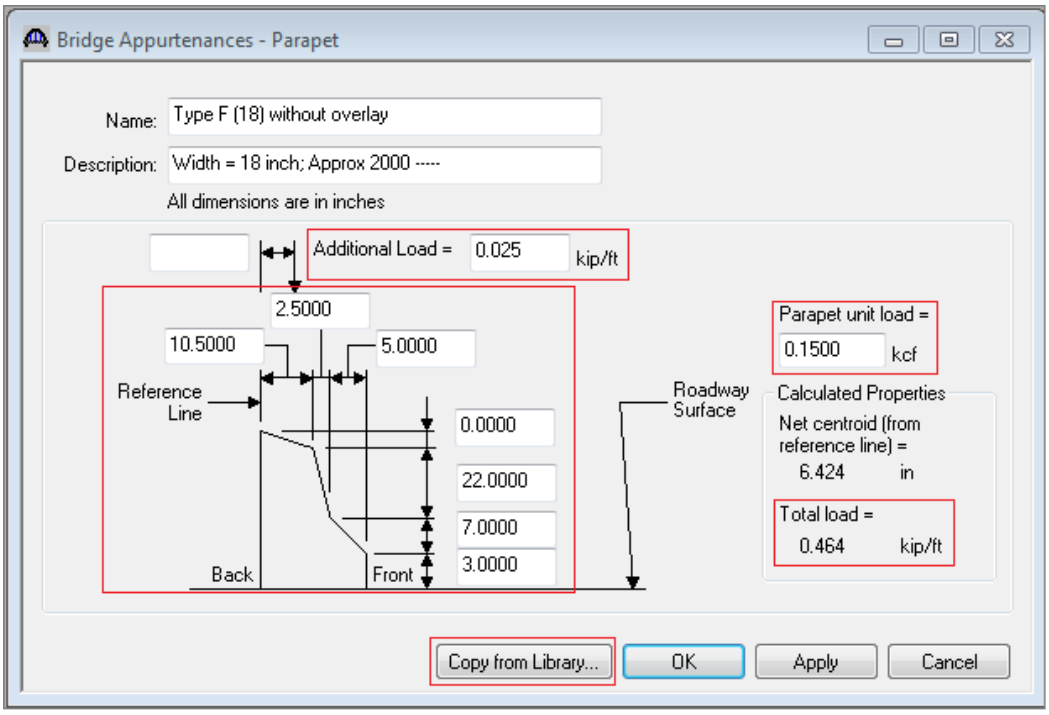


c. The beam properties are copied to the I Beam window as shown below.

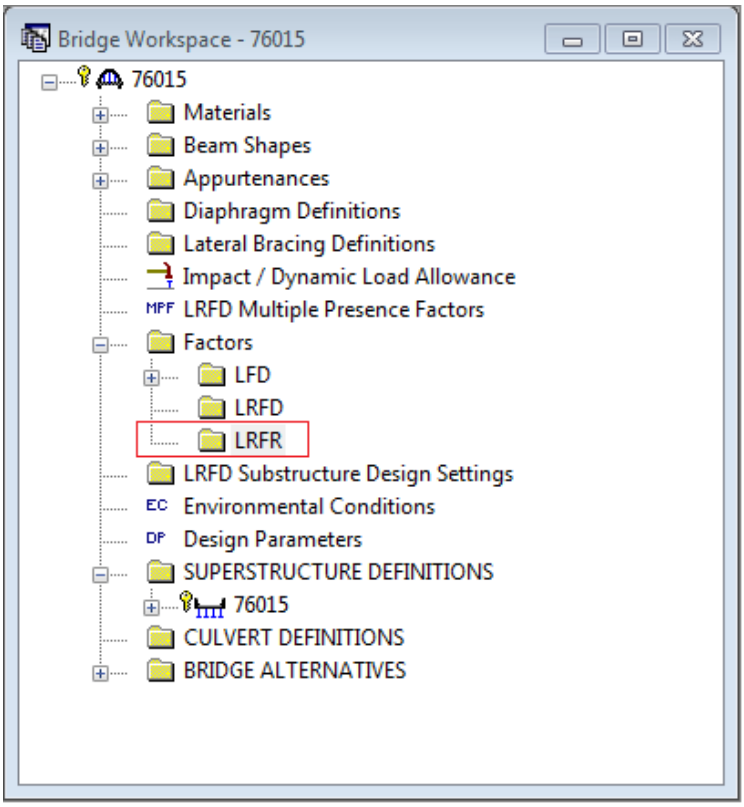


d. Click OK to save the data to memory and close the window

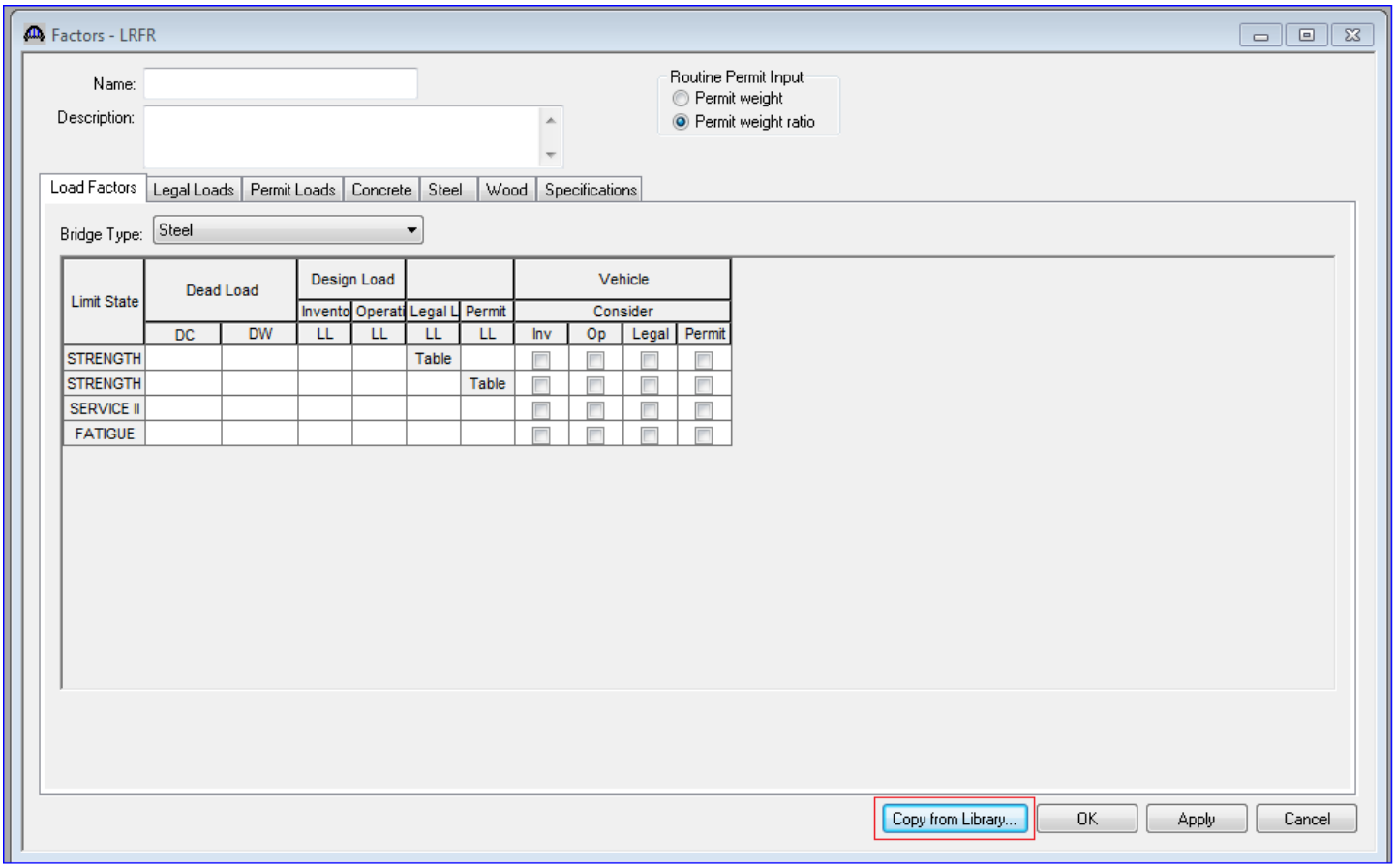
6. To enter the appurtenances to be used within the bridge, expand the tree branch labeled Appurtenances. To define a parapet double click on Parapet in the tree and input the parapet dimensions or click on “Copy from Library” as shown below. Modify values to match dimensions and Total load. Concrete total load is calculated from dimensions given in the diagram below and parapet unit load (concrete unit weight). User may add or subtract (enter negative value) load from Total load in Additional Load box. Click OK to save the data to memory and close the window.



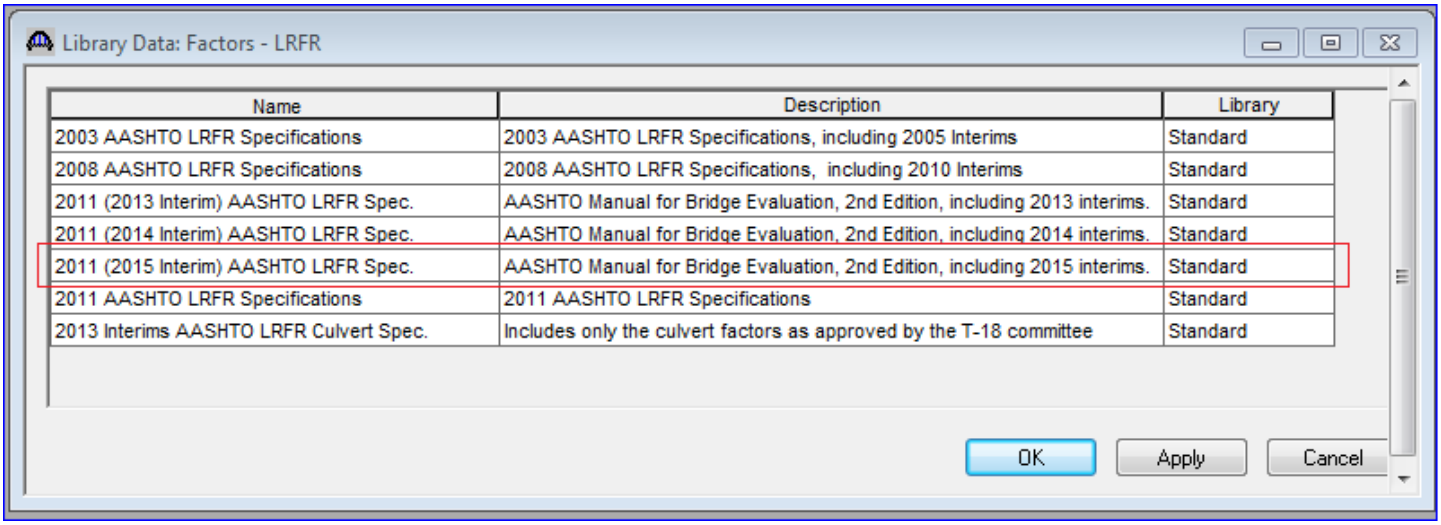
7. If applicable, raised median can be entered on median tab, expand the tree branch labeled Median. To enter information, follow step 6.
8. The default Standard impact factors will be used.
9. To enter LRFR factors, expand the tree branch labeled Factors. Double click on LRFR in the tree to open the Factors window.



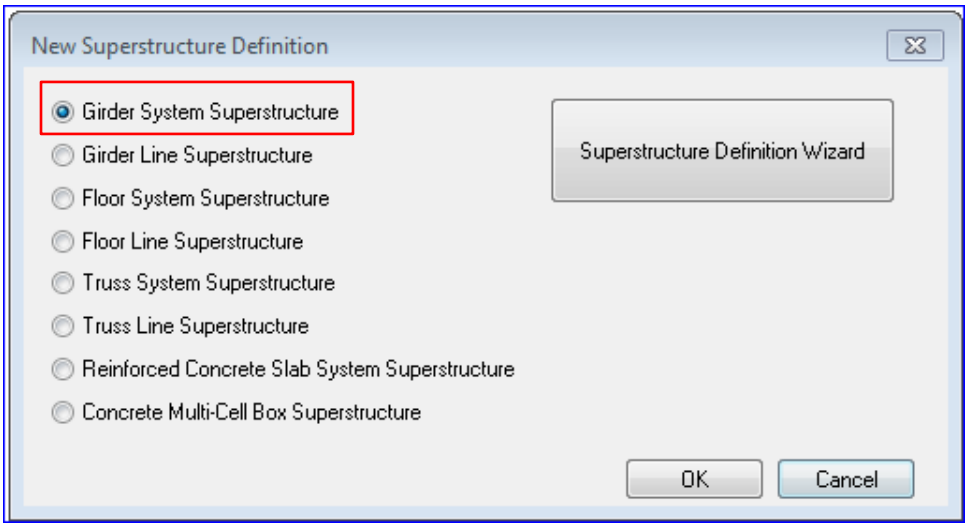
a. Click on “Copy from Library” button as shown below. This will open the window for Factors library data.



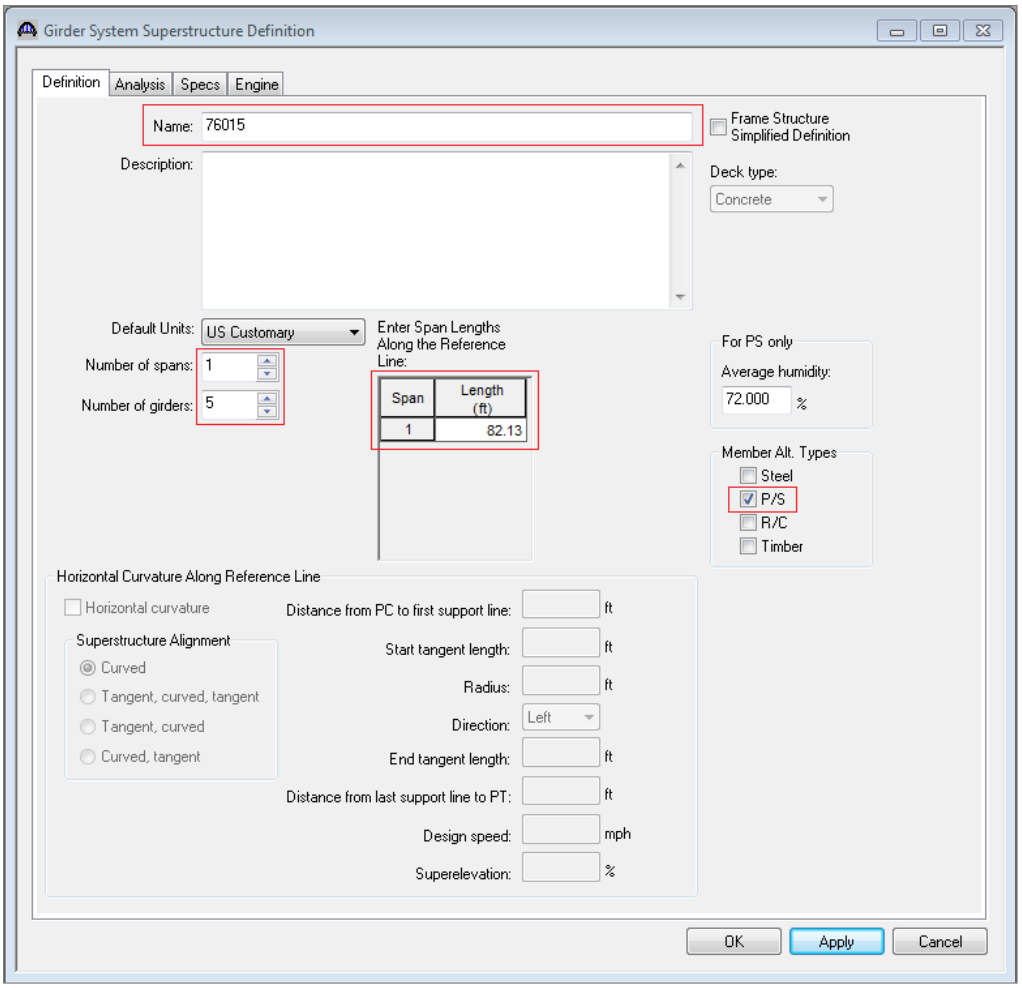
b. Select the most current AASHTO Specifications, "*AASHTO Spec, 2011 (2015 Interim) AASHTO LRFR Spec.*" as shown below. Click OK to save the data to memory and close the window.



10. To create the superstructure type for the bridge, double click on SUPERSTRUCTURE DEFINITIONS (or click on SUPERSTRUCTURE DEFINITIONS and select File/New from the menu or right mouse click on SUPERSTRUCTURE DEFINITIONS and select New from the popup menu) to create a new structure definition. The following dialog will open.



a. Select Girder System and click OK and the Structure Definition window will open. Enter the appropriate data as shown below and check P/S box (for PCB). Click on OK to save the data to memory and close the window.

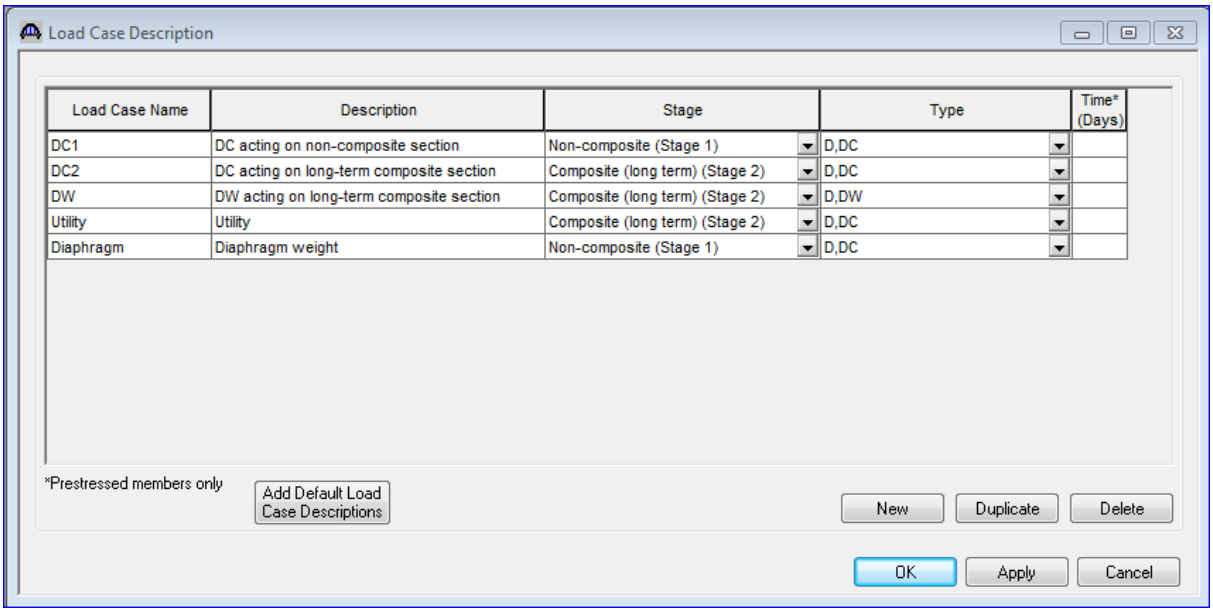


11. Click Load Case Description to define the dead load cases. The composite Dead Load (DL2) needs to be separated into two (or more) items (lines). This is because LRFR will use different load factors for each of the items.

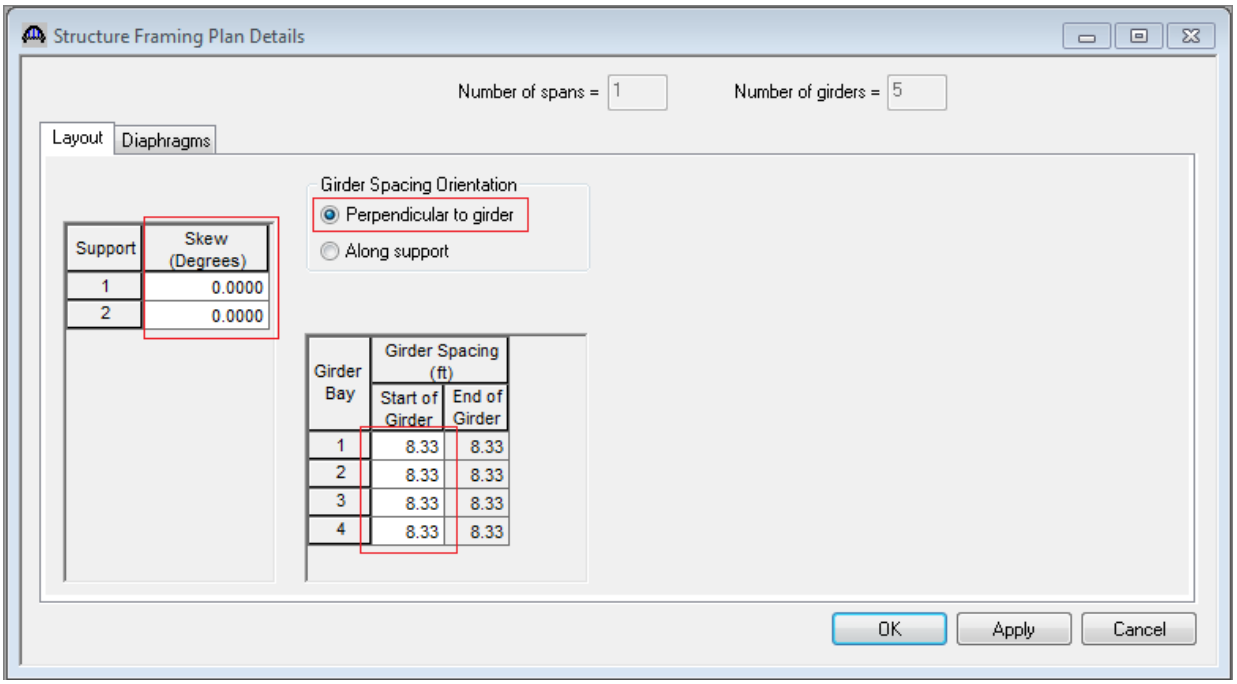
-D, DC includes the original wearing course, railings, median, sidewalk, etc…

-D, DW includes utilities.

Enter the required information and click the OK button. The completed Load Case Description window is shown below.

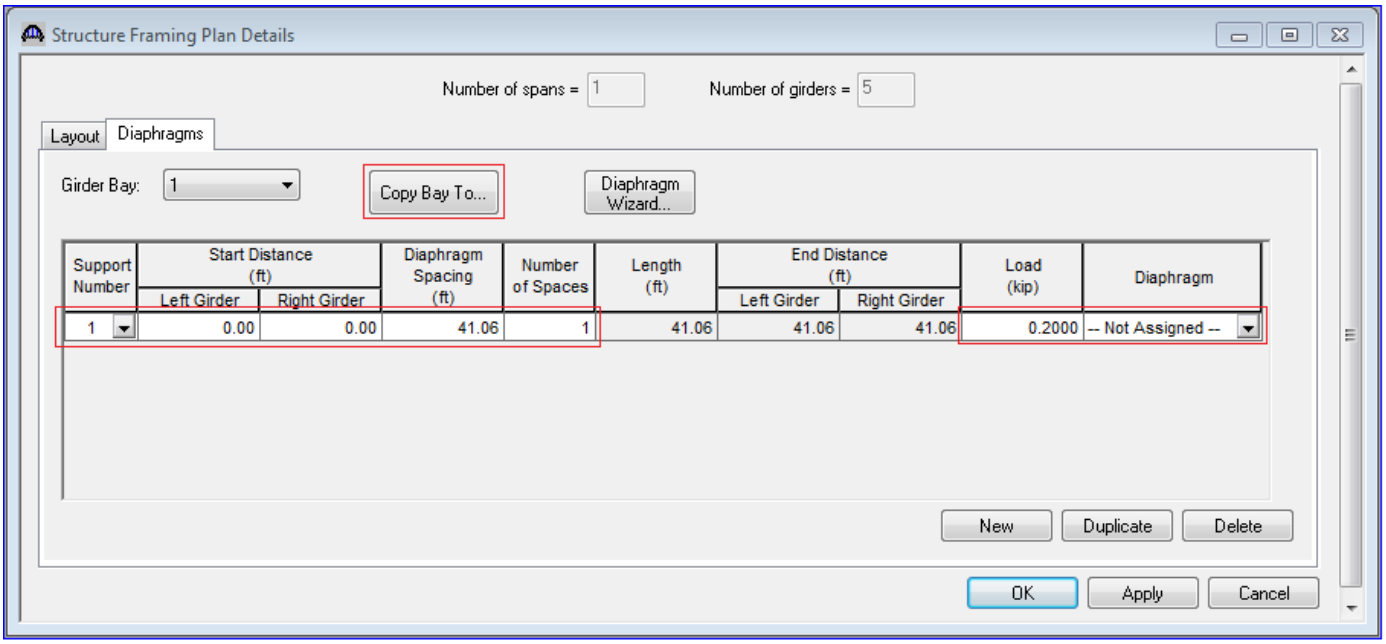


12. Double-click on Framing Plan Detail to describe the framing plan. Enter the appropriate data as shown below.



a. Switch to the Diaphragms tab to enter diaphragm spacing. Click New and enter the following diaphragm information in the dialog shown below. Click on Copy Bay To button to copy diaphragm bracing information from Girder Bay 1 to other bays.

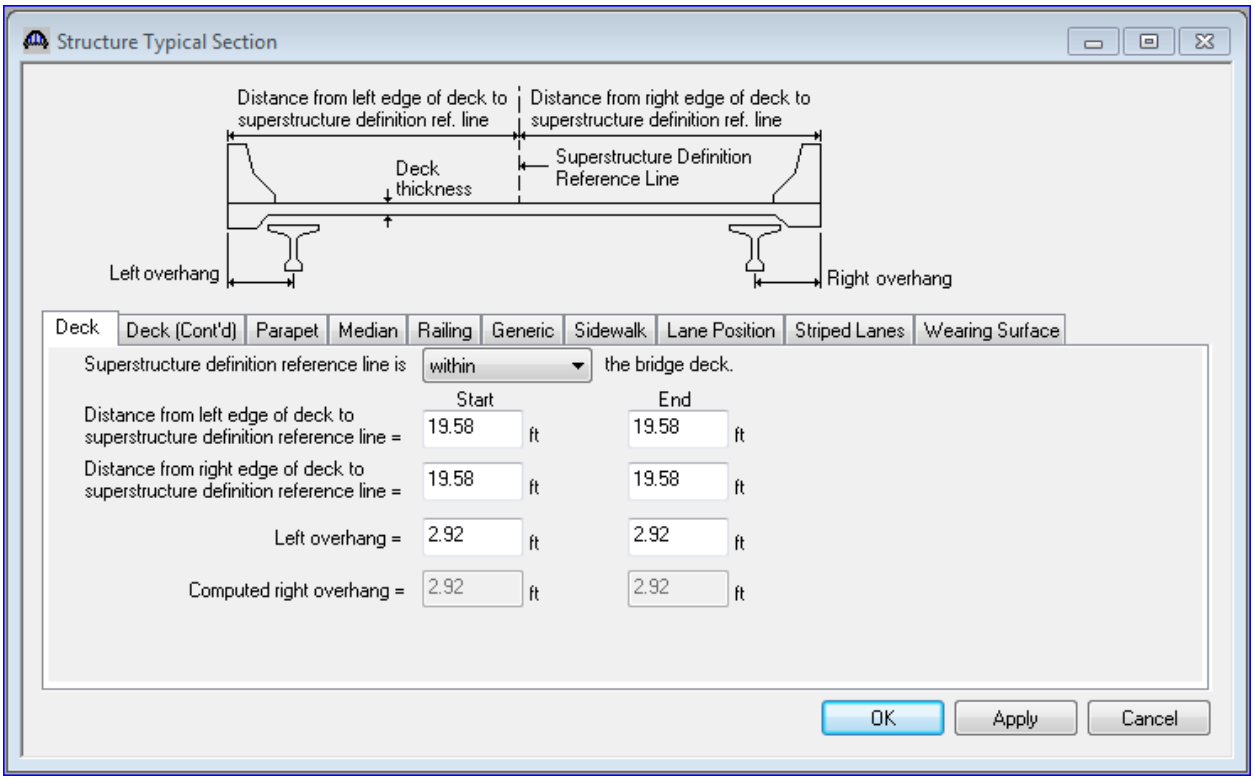
Note: Another option for entering diaphragm load is in the tree branch labeled MEMBERS. For each girder that is created, a point load can be entered in the Concentrated tab in the Member Loads element. See step 19



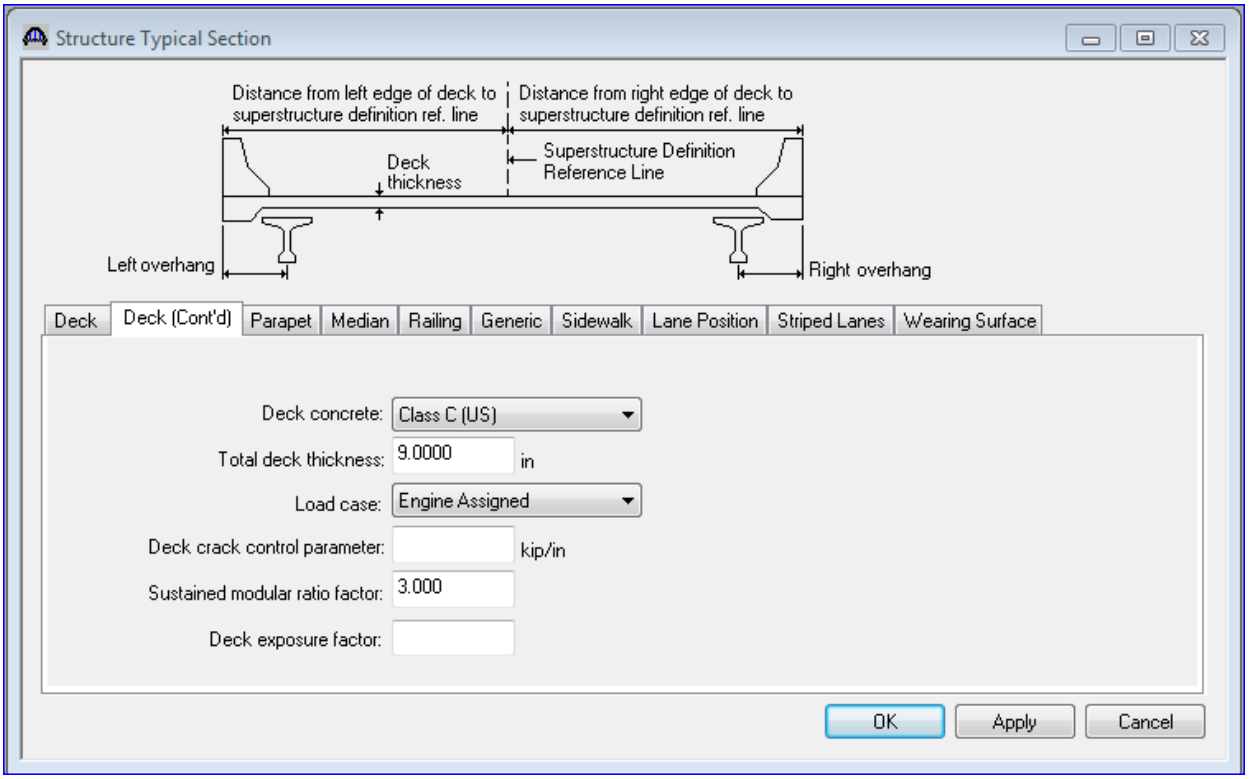
b. Select OK to close the window

13. Next define the structure typical section by double-clicking on Structure Typical Section in the Bridge Workspace tree. If applicable, User can enter typical section information related to the deck, parapets, median, railings, generic barrier, sidewalk, lane position, and wearing surface. Input the data describing the typical section as shown below.

Basic deck geometry:

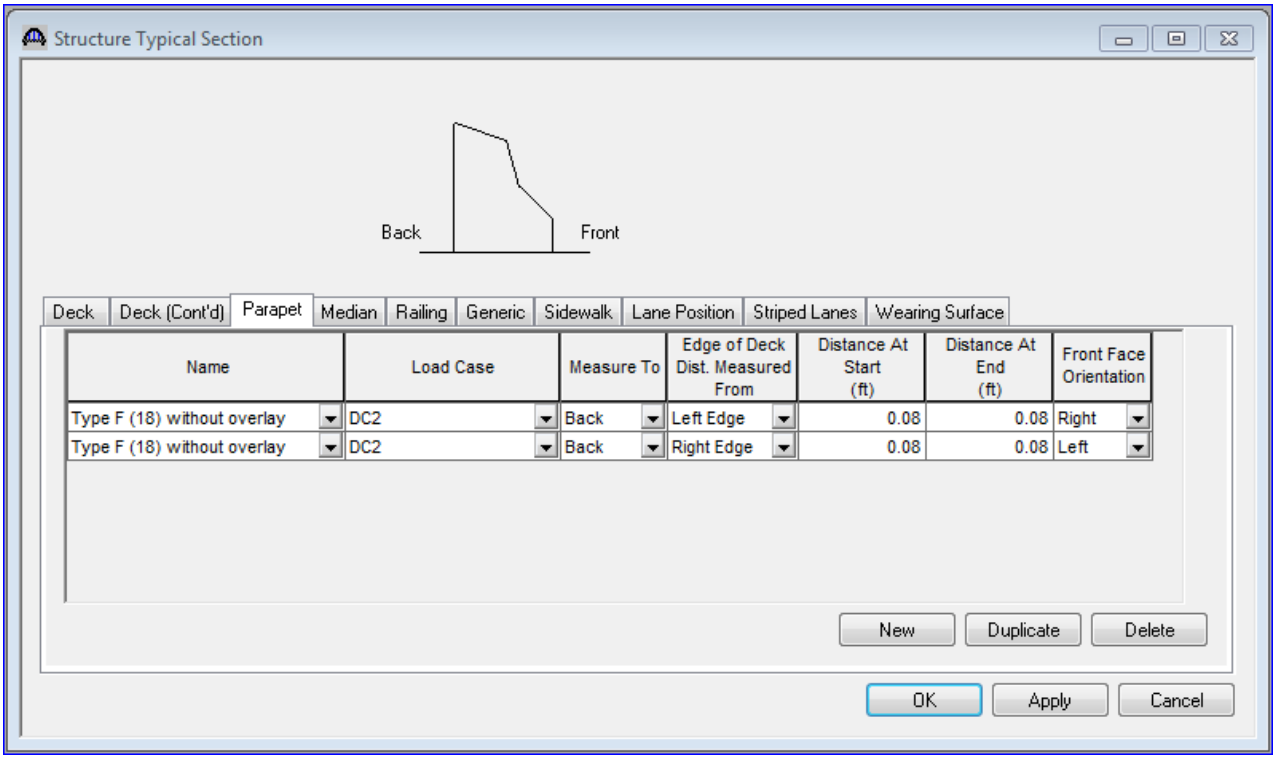


a. The Deck (cont'd) tab is used to enter information about the deck concrete and thickness. Enter total deck thickness as indicated in the plan (no deduction for wearing surface).



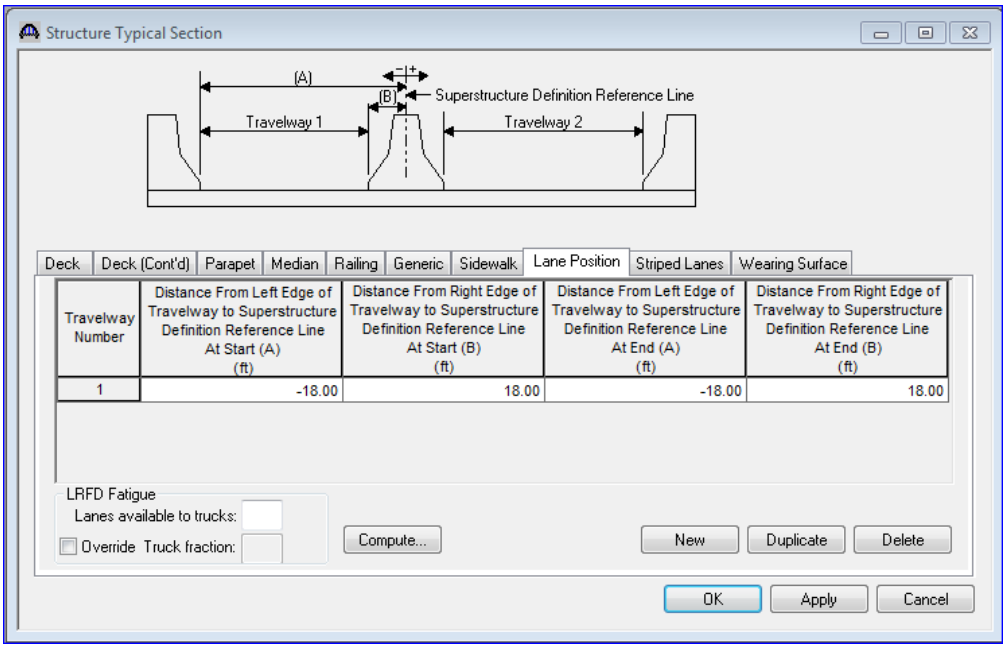
Parapets:

14. Add two parapets as shown below.



Lane Positions:

15. Select the Lane Position tab and use the Compute… button to compute the lane positions. A dialog showing the results of the computation opens. Click Apply to apply the computed values. The Lane Position tab is populated as shown below.

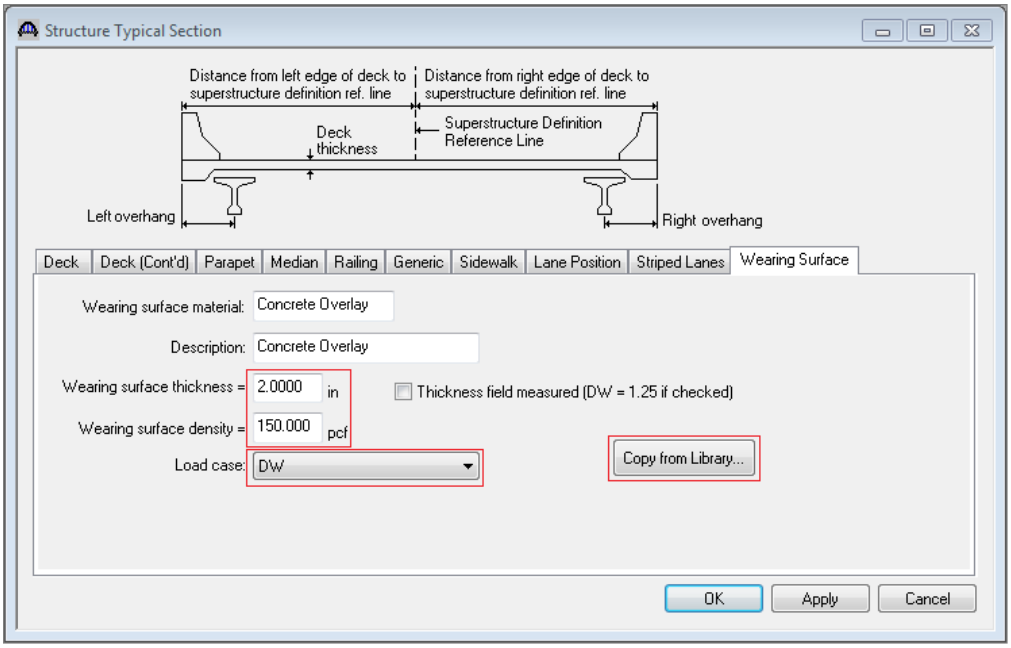


Striped Lanes:

16. Ignore this tab

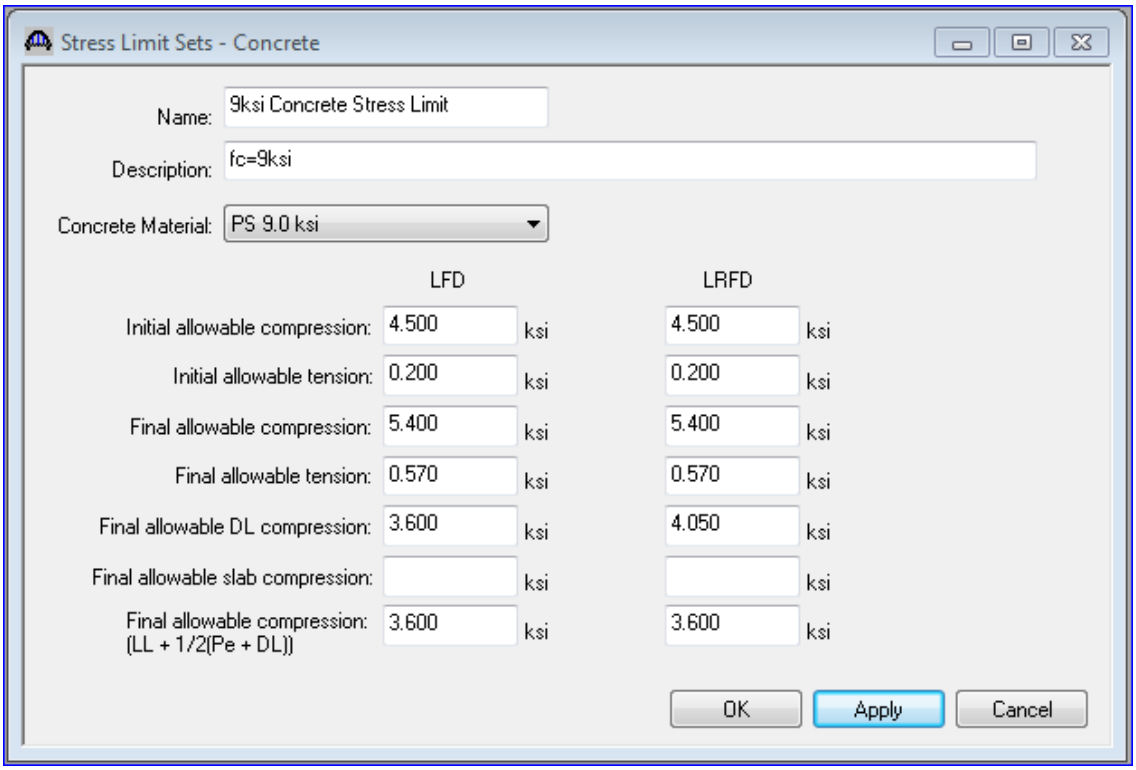
Wearing Surface:

17. Since the plan calls for no wearing surface, it is not required that this tab is filled out. To show how a User would complete the section, data were entered as shown below.



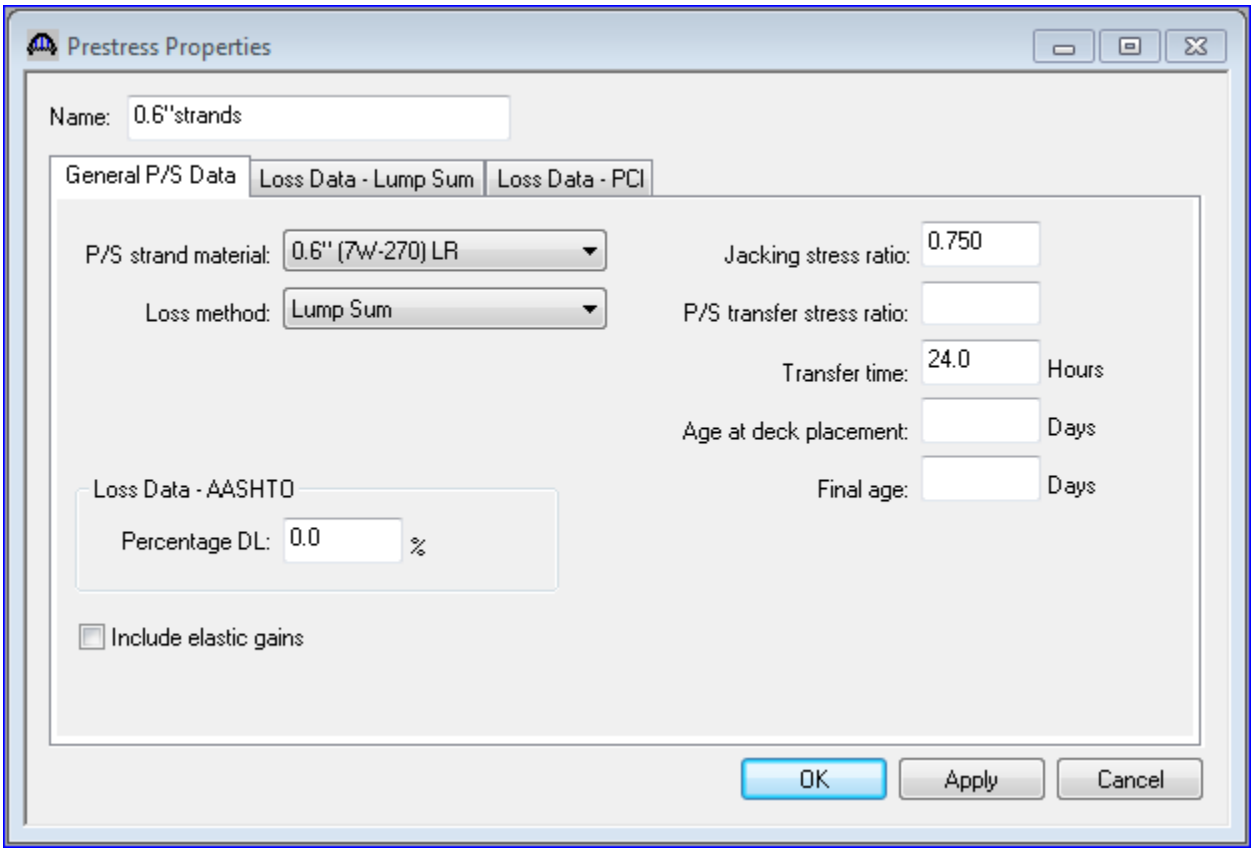
a. Click OK to save the data to memory and close the window.

18. Now define a Stress Limit. A Stress Limit defines the allowable concrete stresses for a given concrete material. Double click on the Stress Limits tree item to open the window. Select the "PS 9.0 ksi" concrete material. Default values for the allowable stresses will be computed based on this concrete and the AASHTO Specifications. A default value for the final allowable slab compression is not computed since the deck concrete is typically different from the concrete used in the beam. Click OK to save this information to memory and close the window.

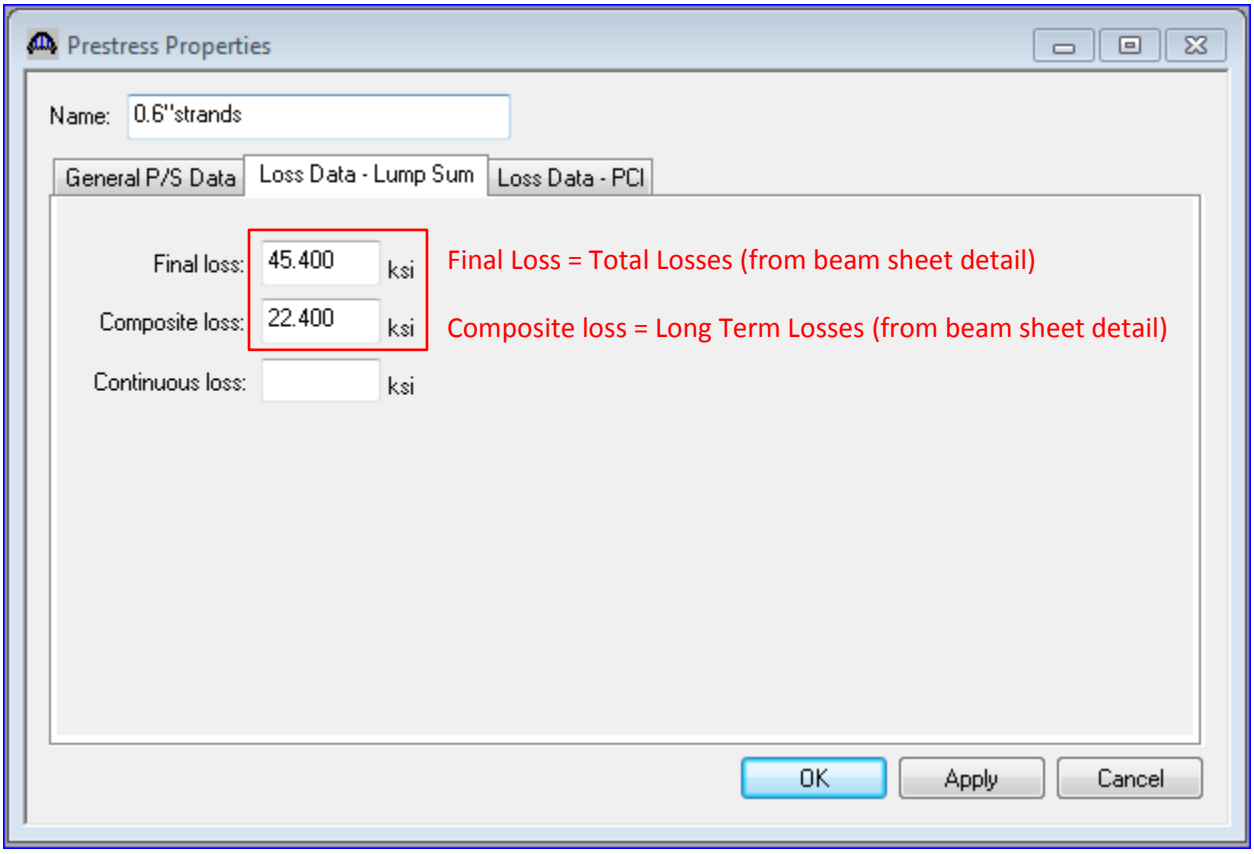


19. Double click on the Prestress Properties tree item to open a window in which to define the prestress properties for this structure definition. Define the Prestress Property as shown below. MnDOT uses the Lump Sum Method to compute losses so both "General P/S Data" and "Loss Data – Lump Sum" tabs are visited.

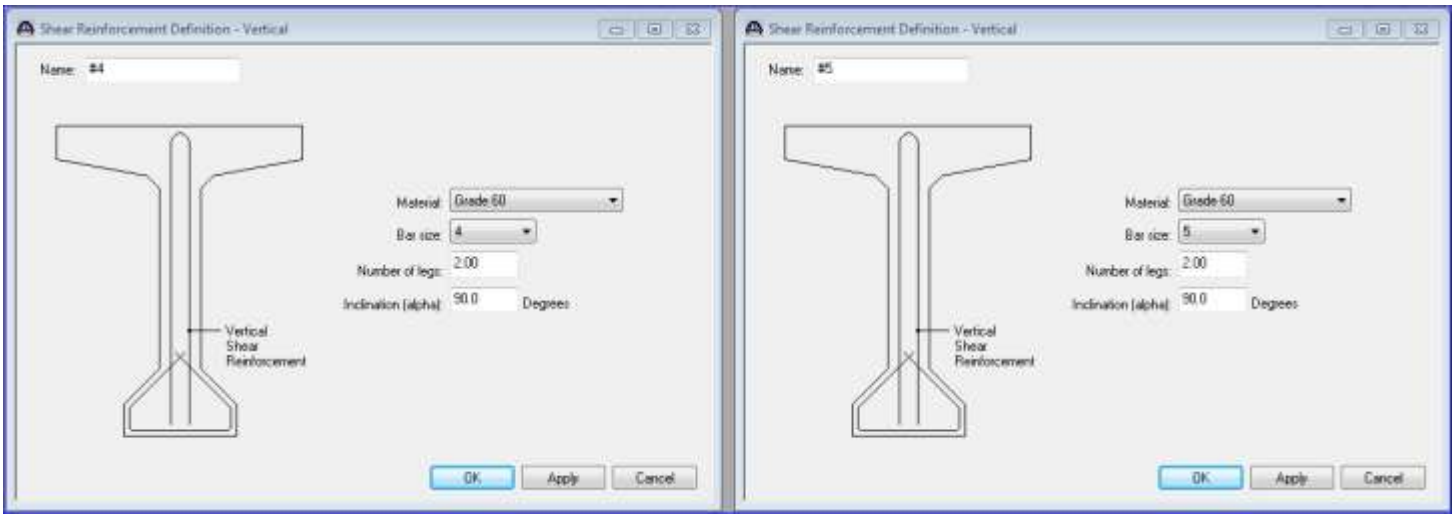
Note: Bridges built prior to Oct. 2009 are rated using LFR method. For this method of analysis, MnDOT uses the AASHTO Approximate method to compute losses so the "General P/S Data" tab is the only tab that User will have to visit. For bridges build on or after Oct. 2009, Lump Sum Method should be used.



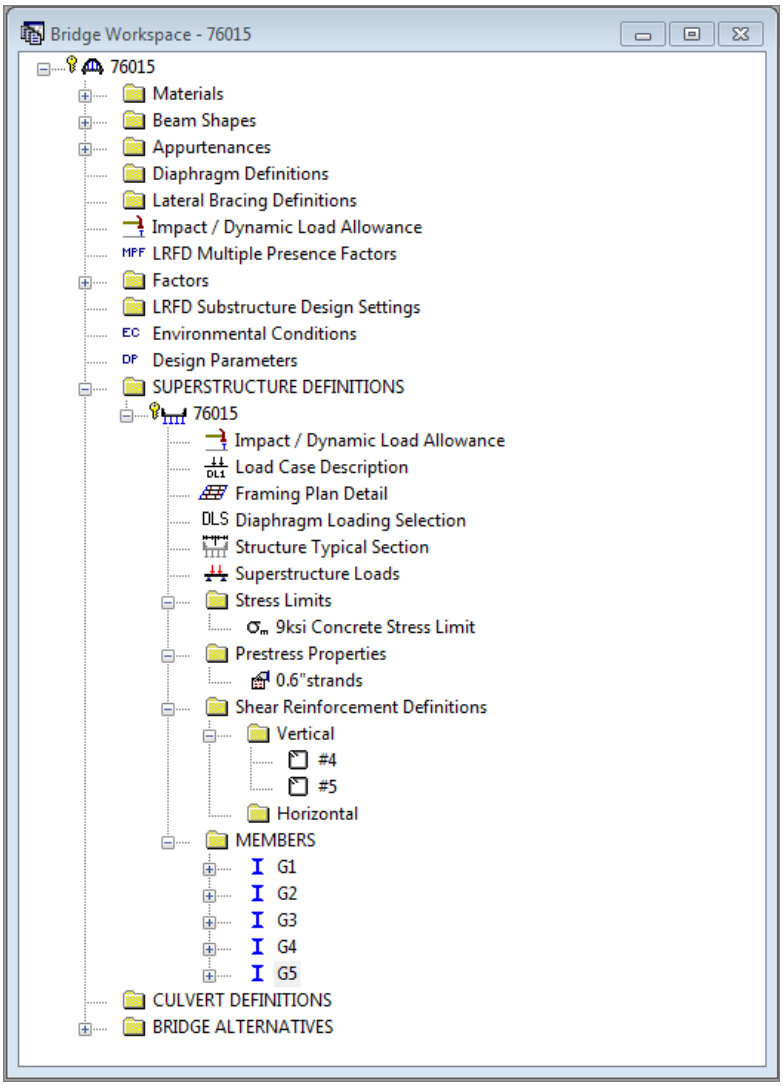
a. For the Loss Data – Lump Sum tab, enter the Final loss and Composite loss values from the beam detail section of the bridge plan. See image below. Click OK to save to memory and close the window.



20. Now define the vertical shear reinforcement by double clicking on Vertical (under Shear Reinforcement Definitions in the tree). Define the reinforcements (#4 and #5) as shown below. Click OK to save to memory and close the window.

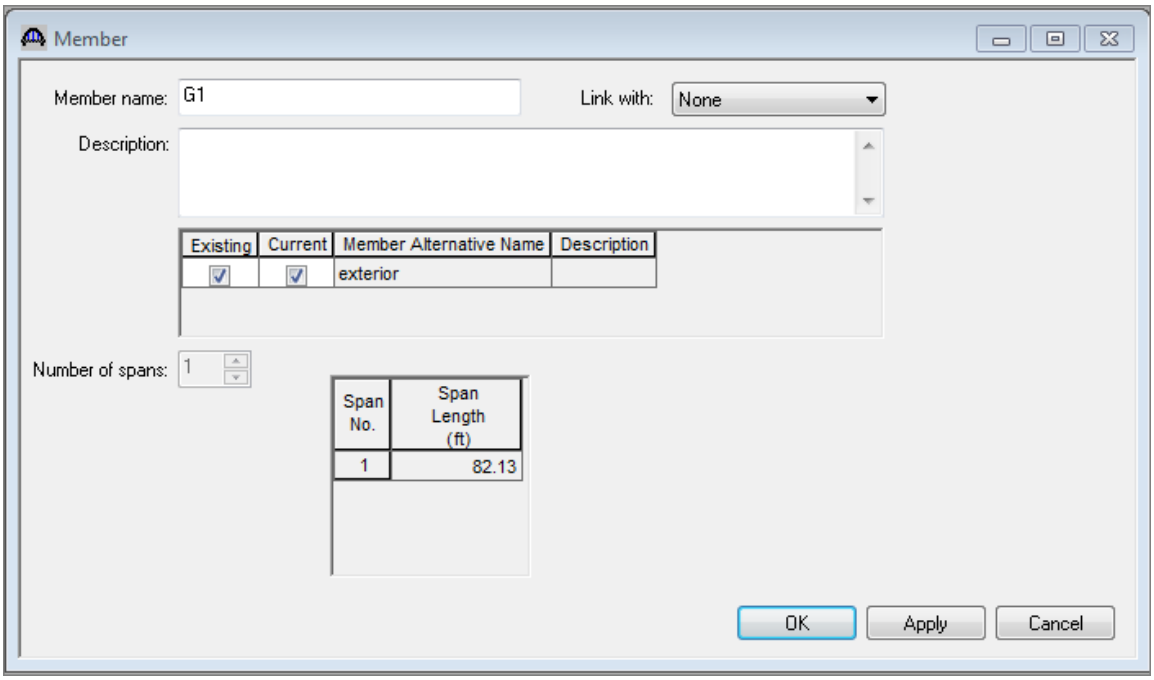


A partially expanded Bridge Workspace is shown below.



Describing a member: Exterior Beam

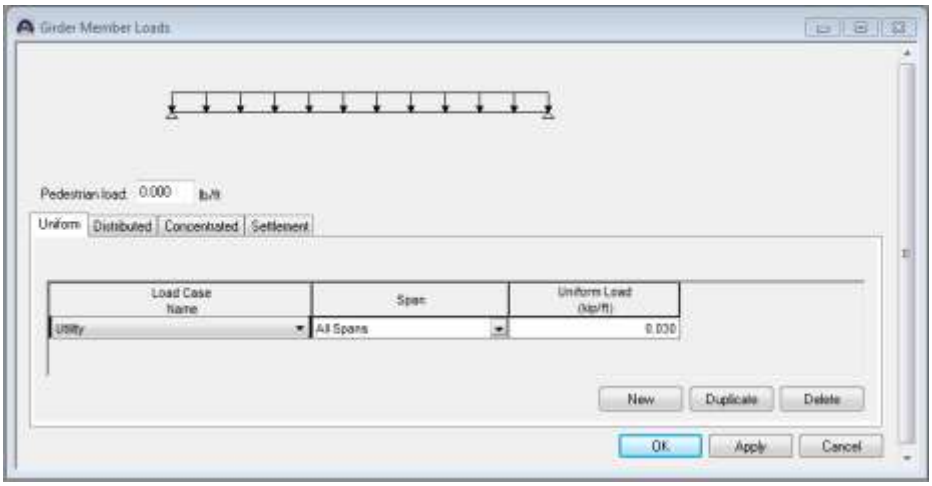
21. The G1 member window (see image below) shows the data that was generated when the structure definition was created. No changes are required at this time. The first Member Alternative that we create will automatically be assigned as the Existing and Current Member alternative for this Member.



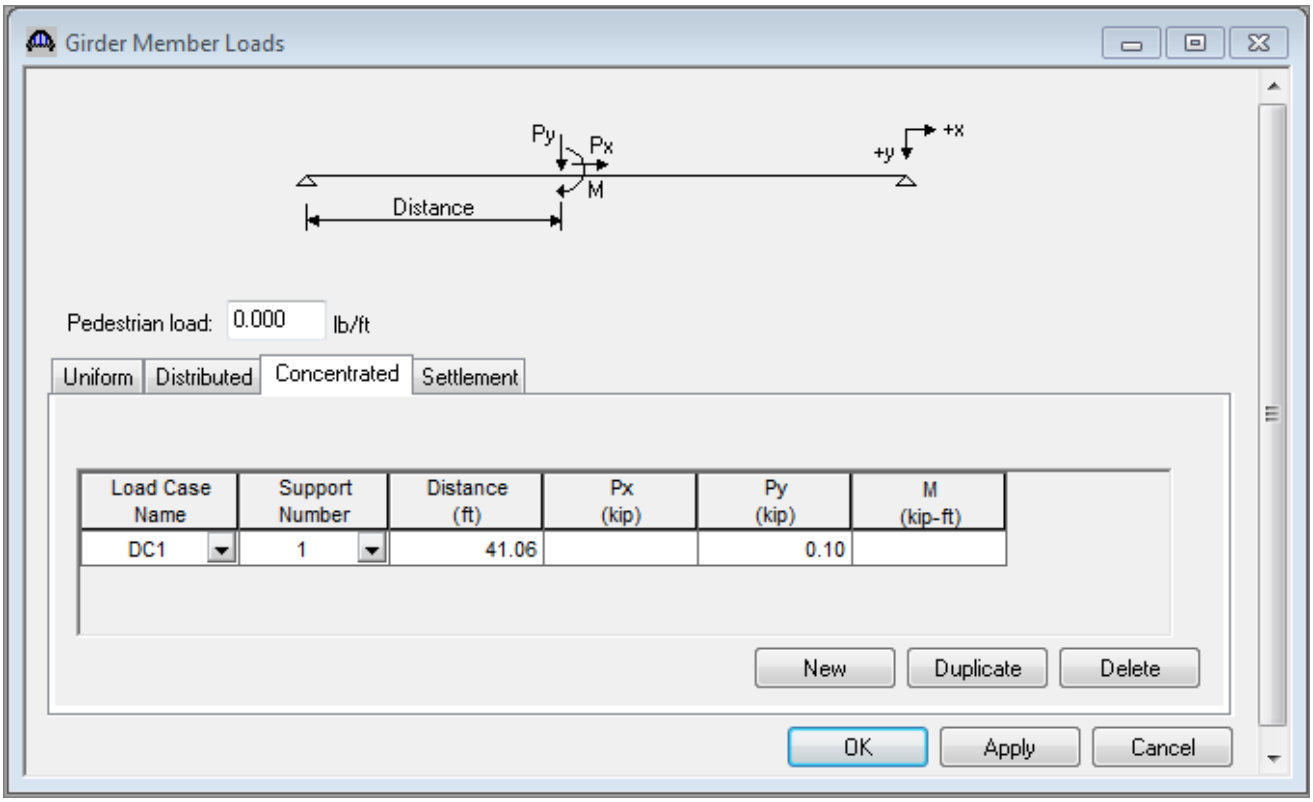
22. Utility load is entered in the Member Loads section under the G1 member in the tree. Double-click Member Loads in the tree to open the window. Under the Uniform tab, select load case that is to be applied, select the span(s) for which the uniform load is to be entered and enter the magnitude of the uniform load as shown below.

MnDOT Design Policy Item:

Note: Unless otherwise confirmed by inspection, include a dead load for utilities of 2 psf of deck area in rural areas and 3 psf in cities and urban areas. Higher loads may be required if heavier utilities are shown on the plan or are known to exist.

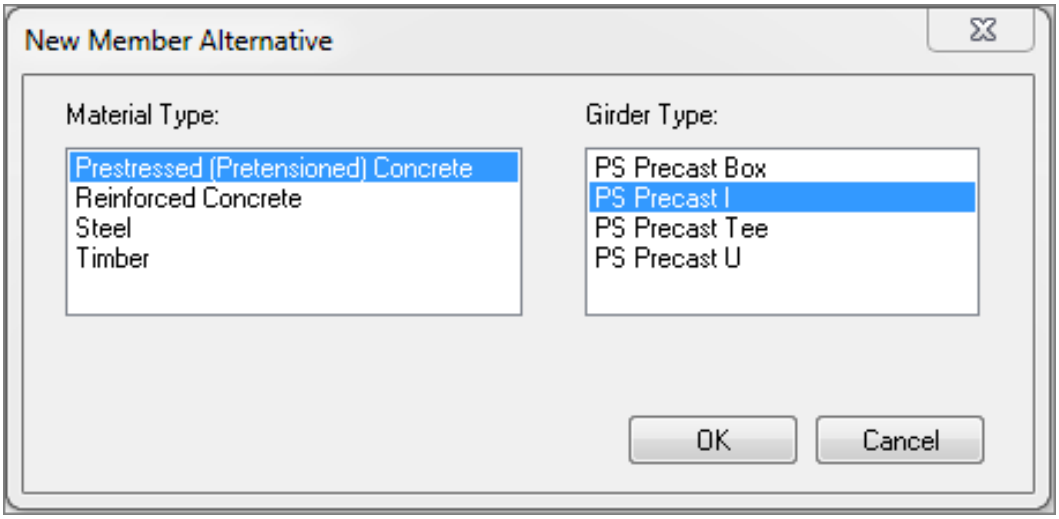


23. As stated earlier (see step 10-a), User has the option of entering Diaphragm load as a concentrated load to act on a member. The Concentrated Tab will allow the User to define the load acting on a member. A sketch is presented illustrating the load type for the selected tab. To show how a User would complete the section, data were entered as shown below. Click OK to save to memory and close the window.



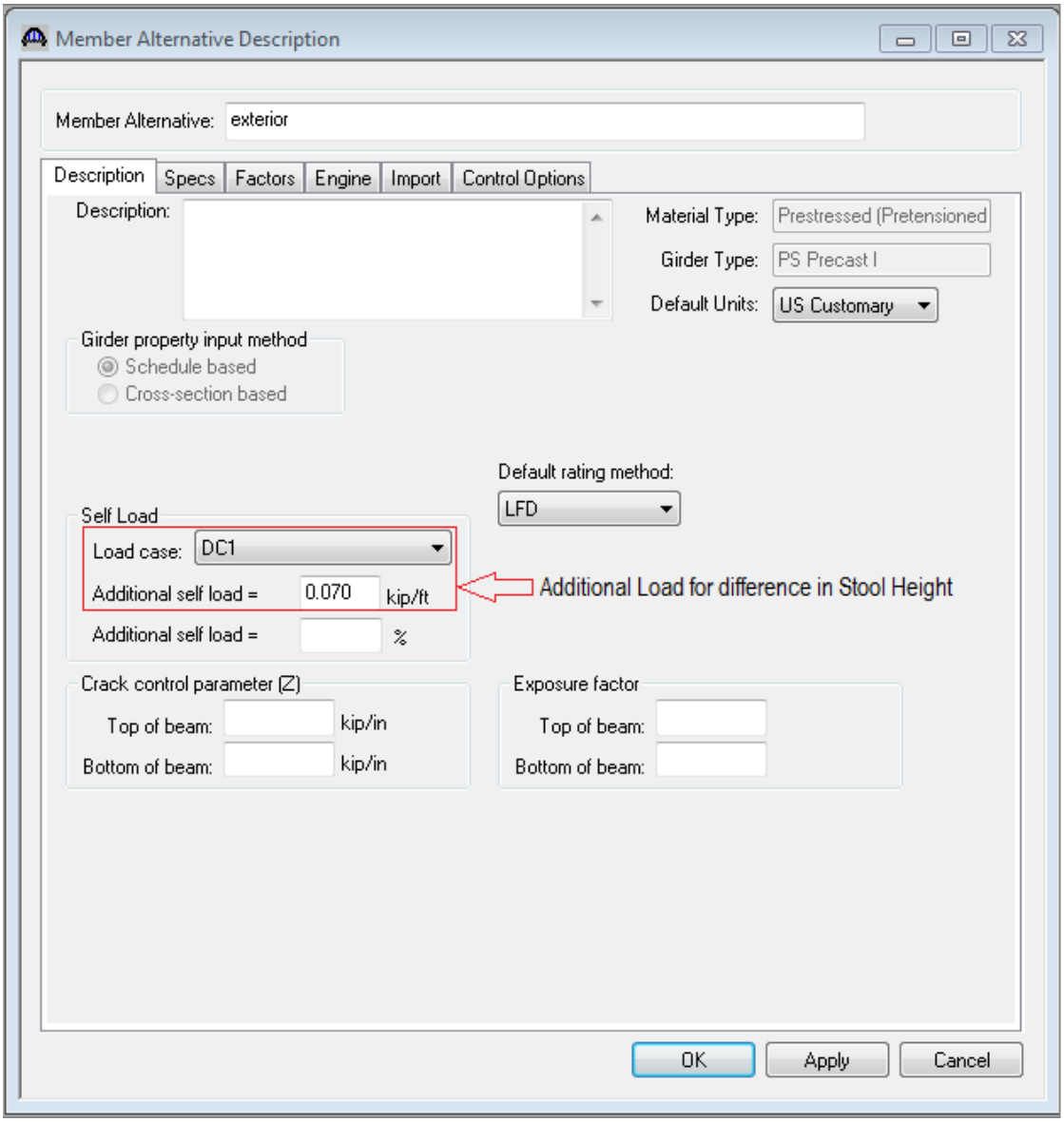
Defining a Member Alternative:

24. Expand the G1 member in the tree. Double-click MEMBER ALTERNATIVES in the tree to create a new alternative. The New Member Alternative dialog shown below will open. Select Prestressed (Pretensioned) Concrete for the Material Type and PS Precast I for the Girder Type.



a. Click OK to close the dialog and create a new member alternative.

25. The Member Alternative Description window will open. Enter the appropriate data as shown below. The Schedule-based Girder property input method is the only input method available for a prestressed concrete beam. To account for the weight of additional stool, residual camber, slope of the deck, super elevation, etc. weight is added in the Self Load section of the Member Alternative Description window as uniform dead load as shown below.



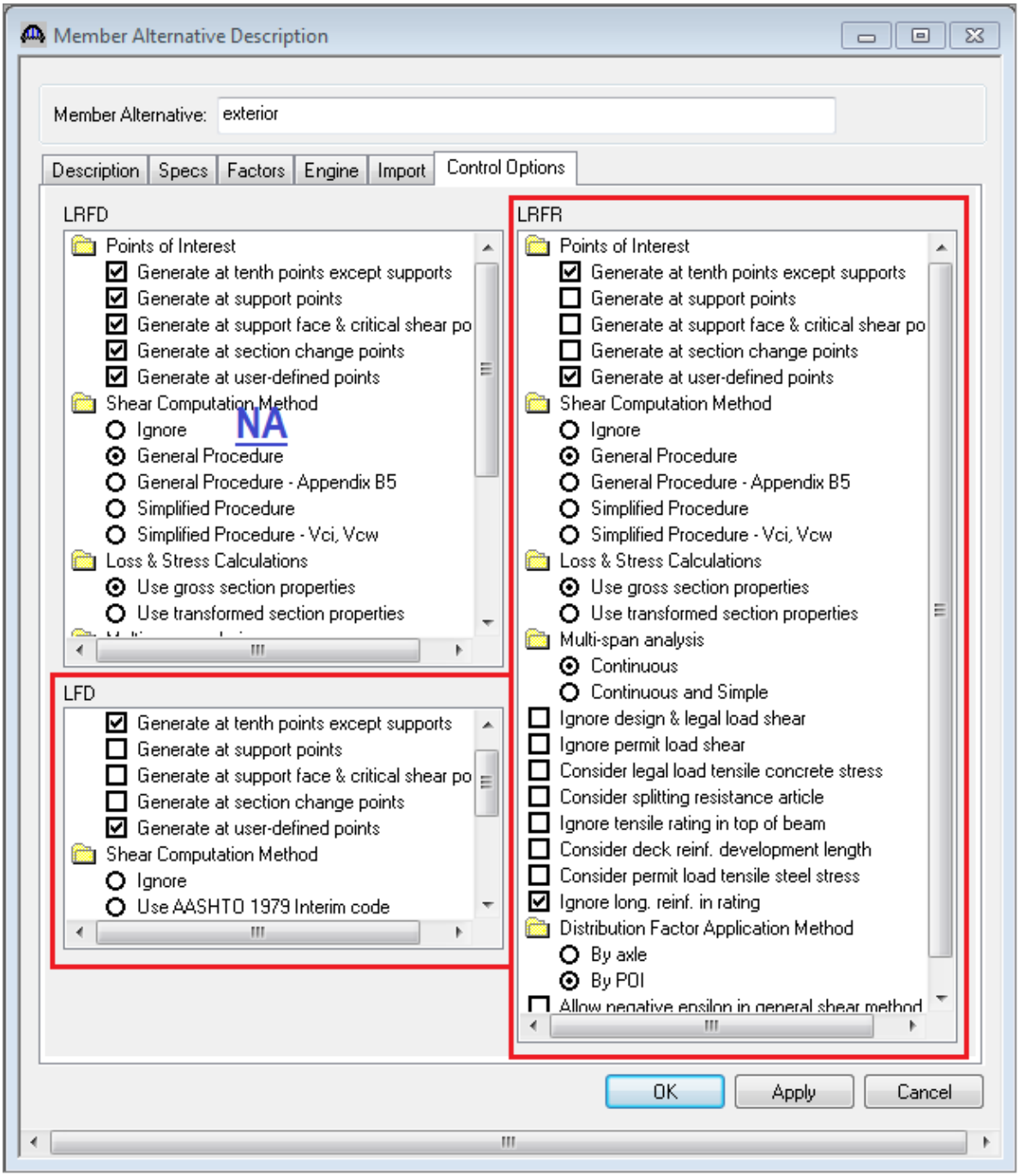
a. Click on the Control Options Tab. For modeling prestressed concrete beams in BrR, select the following LFD and LRFR control options.

For LFD control options (see image below):

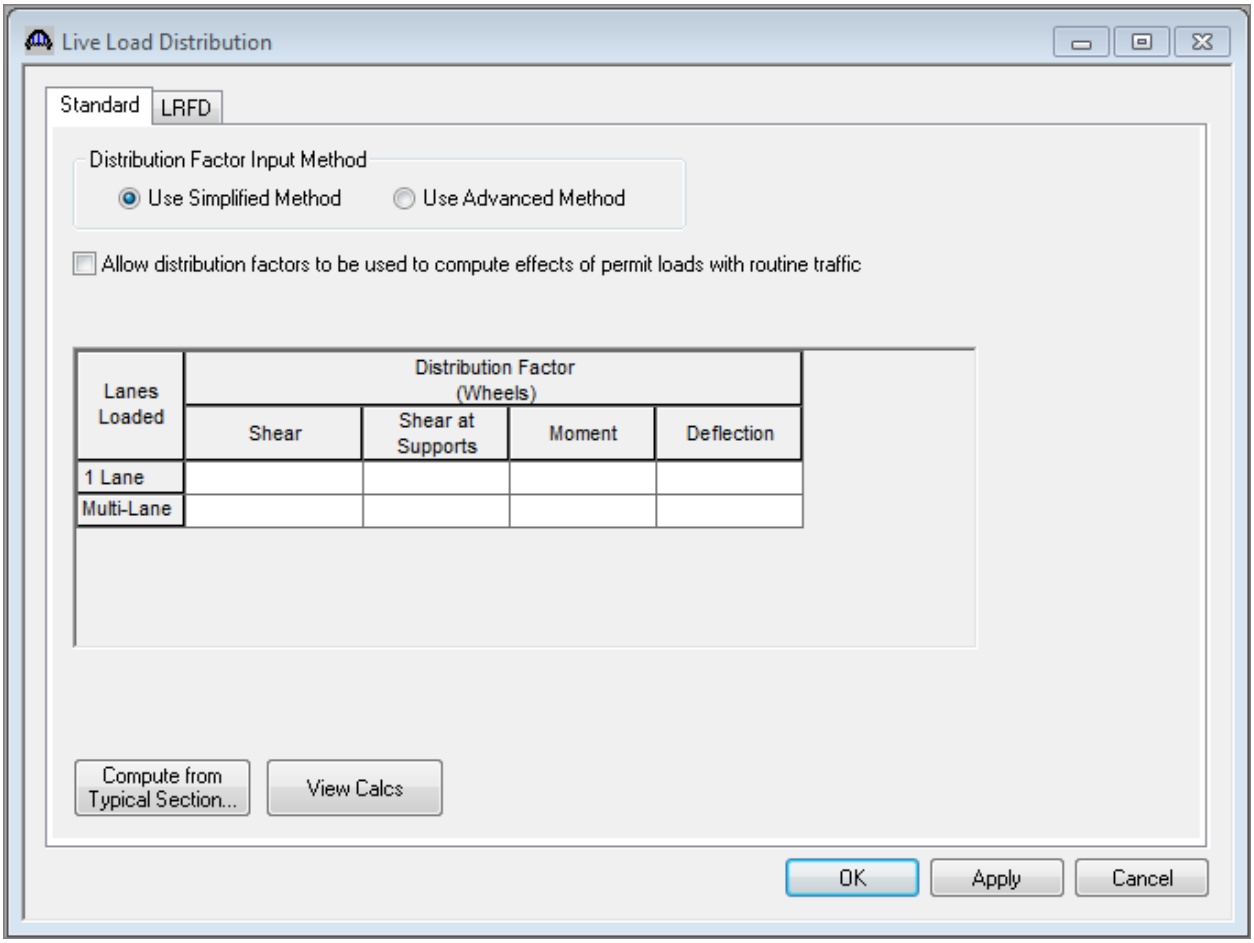
- Points of Interest (POI)
  - Generate at tenth points except supports
  - Generate at user defined points
- Shear Computation Method
  - Use current AASHTO

For LRFR control options (see image below):

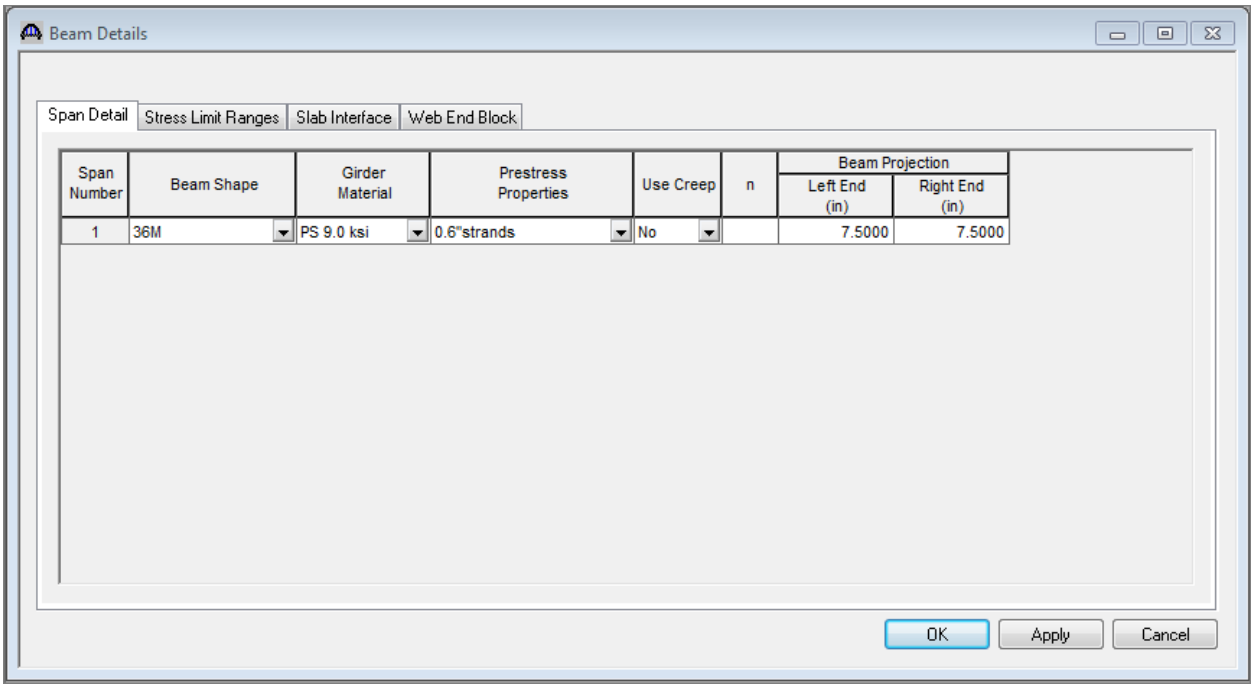
- Points of Interest (POI)
    - Generate at tenth points except supports
    - Generate at user-defined points
- Shear Computation Method
    - General Procedure
- Multi-span analysis
    - Continuous
    - Ignore long. reinf. in rating



26. Double-click Live Load Distribution in the tree to compute the distribution factors from typical section. Standard tab is use for bridges that are Allowable Stress and Load Factor Design. LRFD tab is for bridges that are Load and Resistance Factor Design. If the User tries to use the Compute from Typical Section button on the Standard or LRFD tab to populate the live load distribution factors for this member alternative without creating the rest of adjacent members, you will receive a message that AASHTOWare BrR cannot calculate the distribution factors because beam shapes are not assigned to adjacent member alternatives. This is due to the fact that program does not yet know if we have adjacent prestressed concrete beams. After all members in your superstructure have been created in member alternatives, we can revisit this window to compute the live load distribution factors using the Compute from Typical Section button.

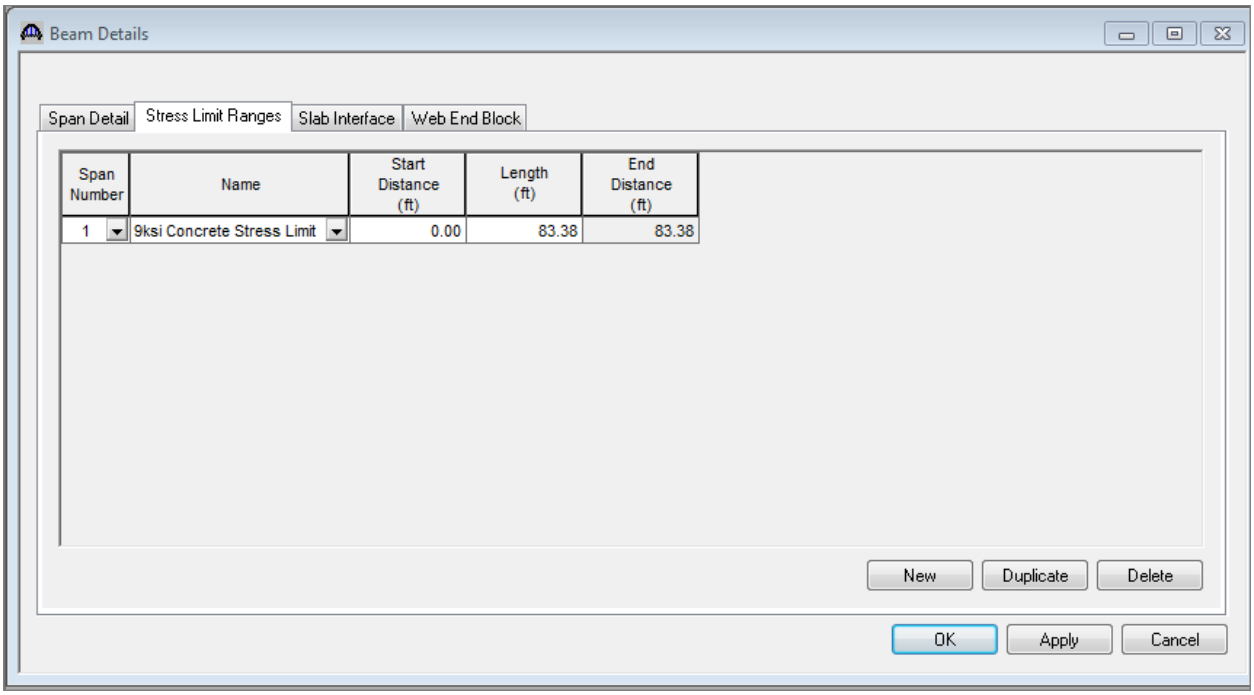


27. Next is to describe the beam by double clicking on Beam Details in the tree. Enter the required information for the beam as shown below. Beam projection is the distance from the end of the beam to the centerline of bearing.



a. Click on the next tab," Stress Limit Ranges", and complete the required information as shown below. Click OK to save to memory and close the window.

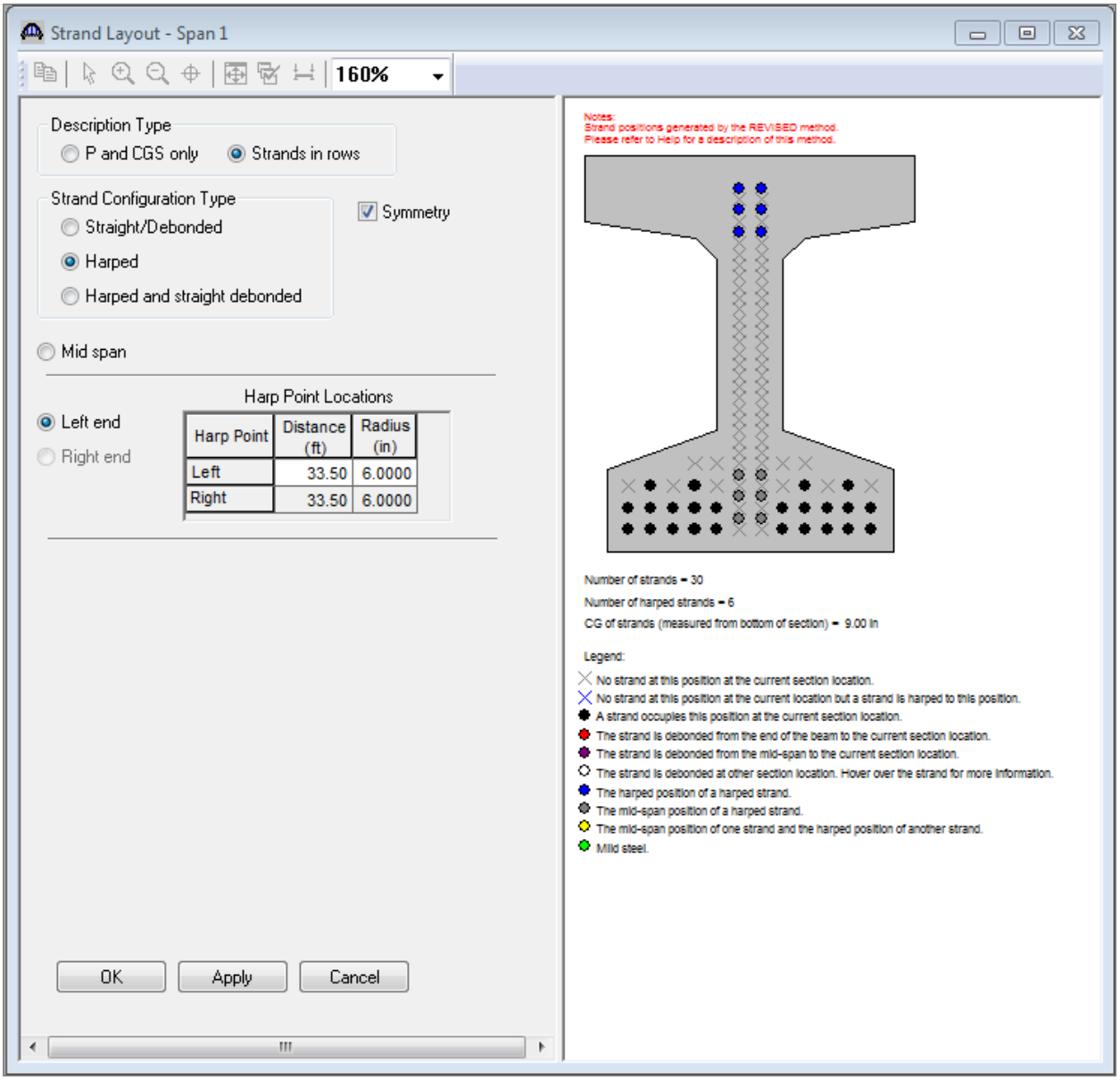
Note: Stress Limit Ranges are defined over the entire length of the precast beam, including the projections of the beam past the centerline of bearing which were entered on the Span Detail tab.



28. Expand the tree under Strand Layout and open the Span 1 window. Place the cursor in the schematic view on the right side of the screen. The toolbar buttons in this window will become active. Select the Zoom button to shrink the schematic of the beam shape so that the entire beam is visible.

a. Select the Description Type as Strands in rows and the Strand Configuration Type as Harped. The Mid span radio button will now become active. You can now define the strands that are present at the middle of the span by selecting strands in the right hand schematic. Select the bottom 30 strands in the schematic so that the CG of the strands is 3.80 inches.

b. Now select the Left end button to enter the following harped strand locations at the left end of the precast beam. Place the cursor in the schematic view on the right side of the screen. You can now define the strands that are present at the left end of the span by selecting strands in the right hand schematic. Select the top, third and fifth row 2 strands in the schematic so that the CG of the strands is 31 inches. Enter Harp Point Locations information. Close the window by clicking OK. This saves the data to memory and closes the window.



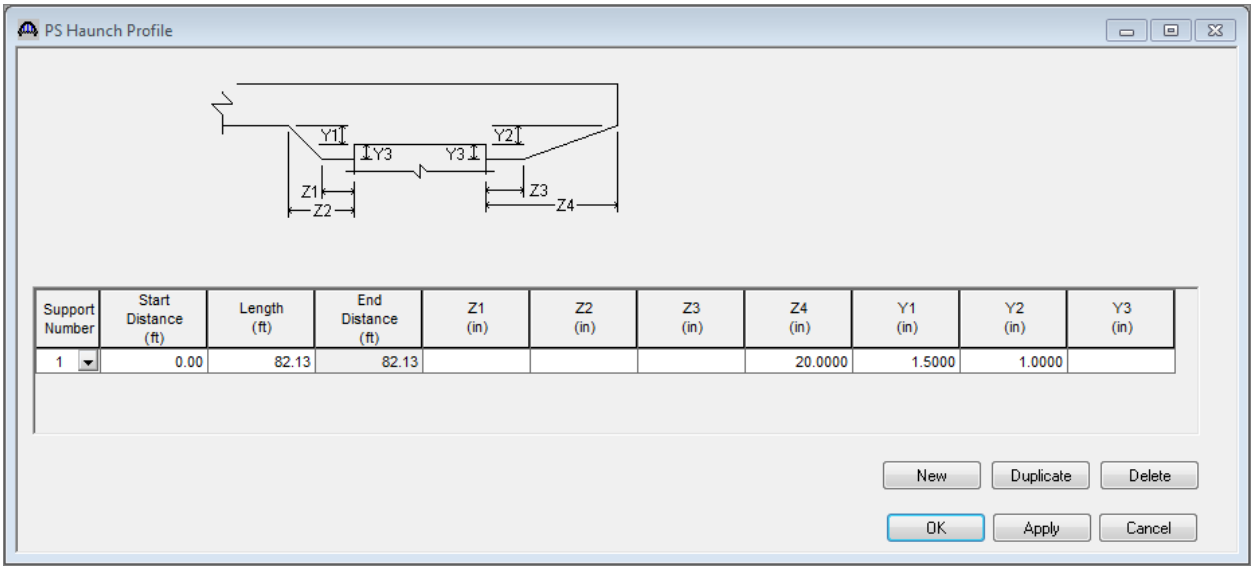
29. Double-click Deck Profile in the tree to describe the structural properties of the deck. If the User tries to use the Compute from Typical Section button to describe the deck profile for this member alternative without creating the rest of adjacent members, we will receive a message that AASHTOWare BrR cannot compute from Typical

Section because beam shapes are not assigned to adjacent member alternatives. After all members in your superstructure have been created in member alternatives, we can revisit this window.

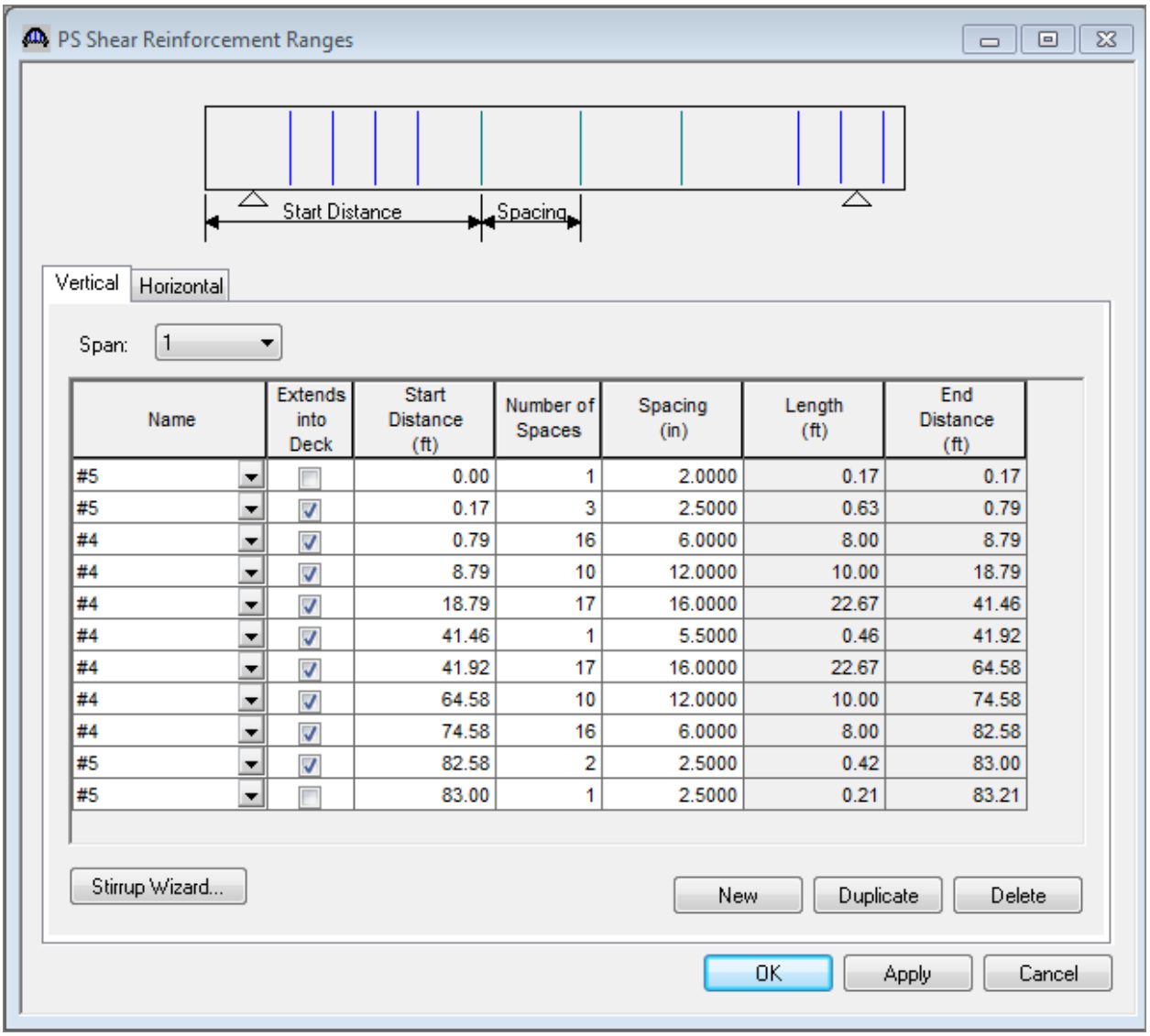
MnDOT Design Policy Item:

The topmost 0.5 inch of the wearing course or slab is not considered to be effective for composite action or section properties.

30. The haunch profile is defined by double clicking on Haunch Profile in the tree. Enter the required information. The window is shown below.

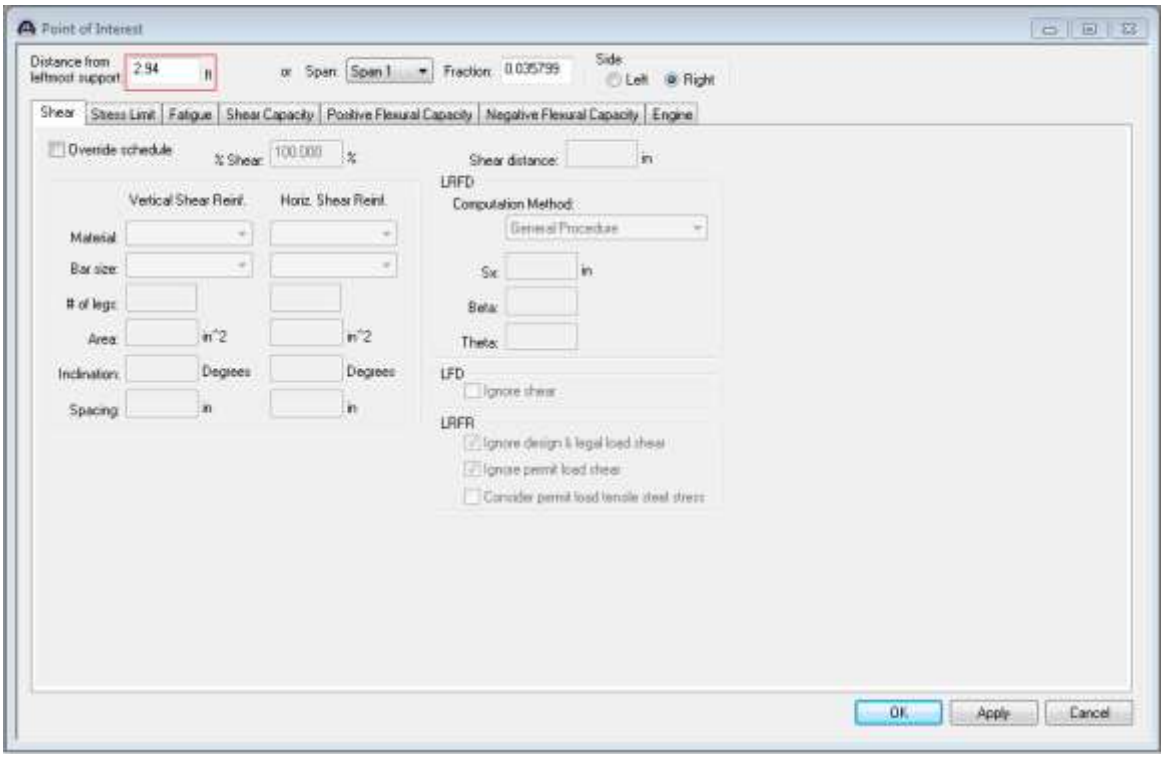


31. The Shear Reinforcement Ranges are entered by double clicking on Shear Reinforcement Ranges in the tree. The vertical shear reinforcement is defined as extending into the deck on this tab. This indicates composite action between the beam and the deck. Data does not have to be entered on the Horizontal tab to indicate composite action since we have defined that by extending the vertical bars into deck. Enter the required information and click the OK button. The window is shown below.



32. Double-click Points of Interest in the tree to define a point of interest on a beam. Enter points of interest at 0.72h. ***Note: For LFR analysis, enter points of interest at h/2***. "h" is the distance from the top of the deck to the bottom of the beam at the centerline of bearing.

$$h = 9\text{in}+4\text{in}+36\text{in}=49\text{in} \qquad 0.72\text{h} = 0.72\left(\frac{49in}{12\frac{in}{ft}}\right) = 2.94\ \text{ft}$$

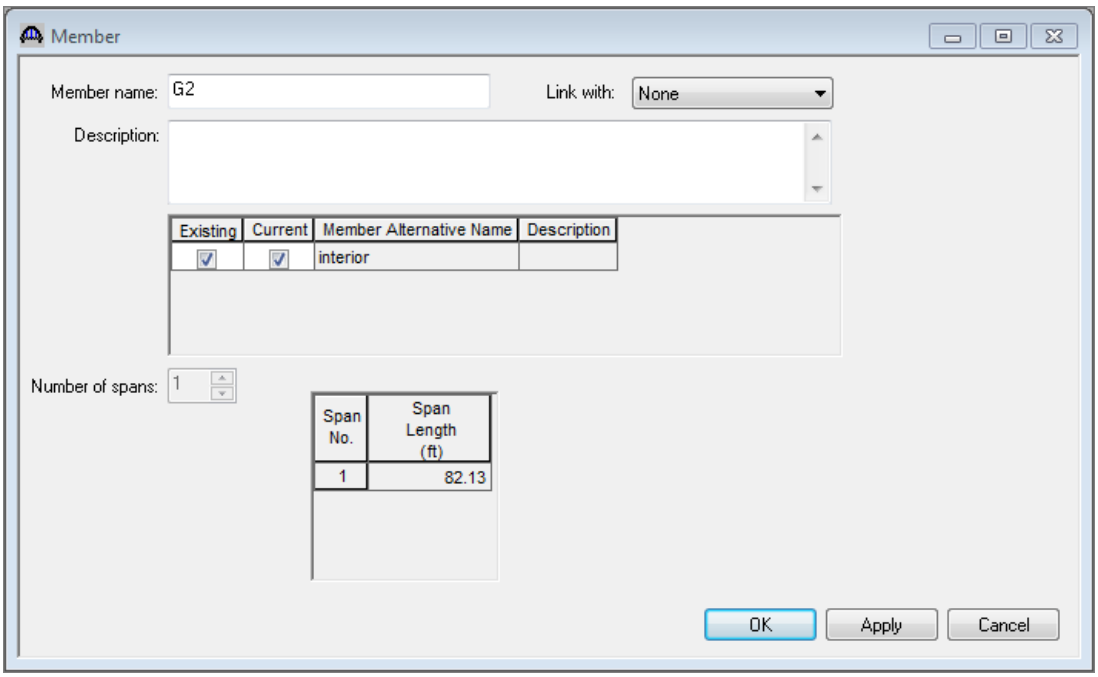


a. Click Apply and then click OK to save to memory and close the window.

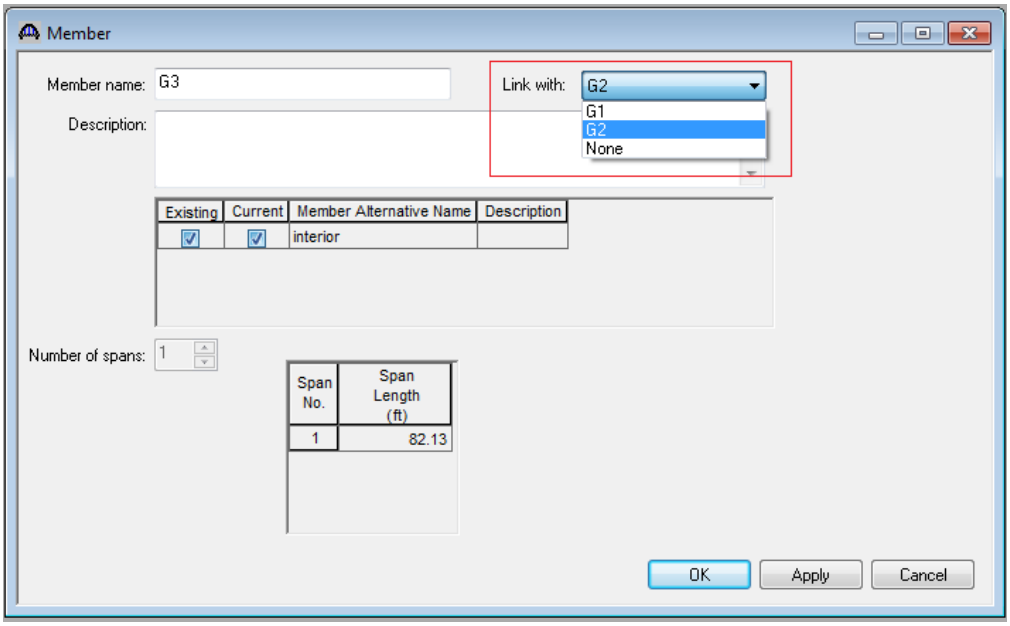
The description of the exterior beam for this structure definition is complete.

Describing a member: Interior Beam

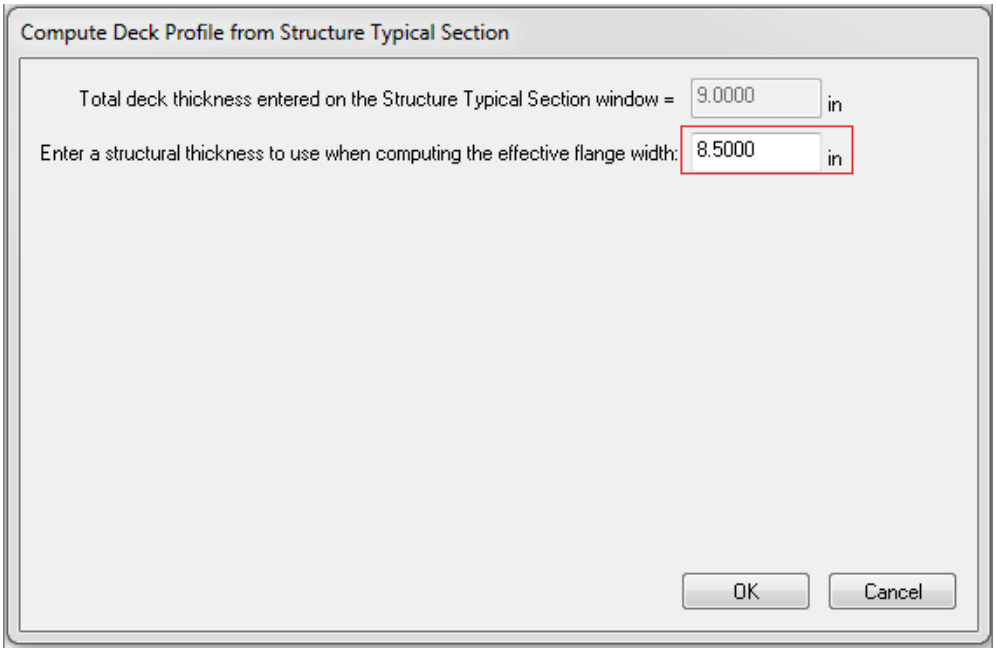
33. The G2 member window (see image below) shows the data that was generated when the structure definition was created. No changes are required at this time. The first Member Alternative that we create will automatically be assigned as the Existing and Current Member alternative for this Member.



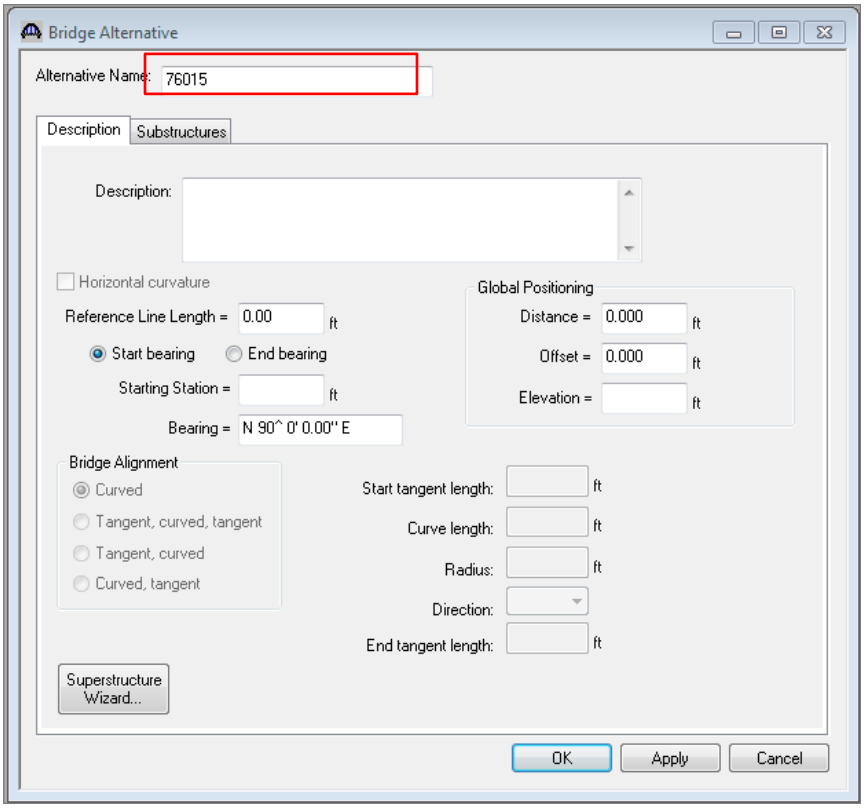
34. Follow steps 21 through 32 to completely define the interior beam (G2).
35. To define the rest of the remaining interior beams and exterior beam, one by one, expand G3, G4 & G5 member in the tree, select from the "Link with" pull down menu to which this member is to be linked as highlighted below. G3 and G4 will be linked with G2 and G5 will be linked with G1. If two members are linked, they share the same definition and any revision to one member affects the other member. If there are any differences between two members, then they should not be linked with one another.



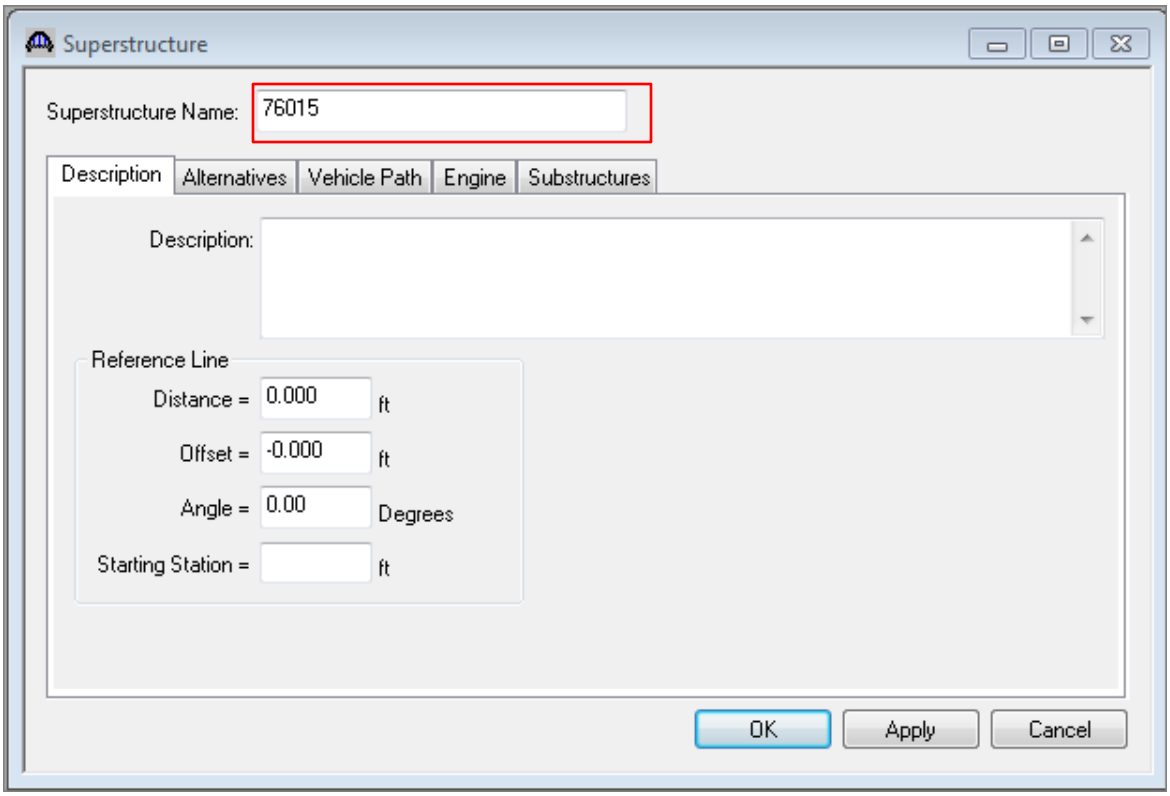
36. Compute LRFD live load distribution factors for the exterior (G1) and interior girders (G2) by double-clicking Live Load Distribution in the tree. Click on Compute from Typical Section button to calculate LRFD live load distribution factors. Click OK to save to memory and close the window.
37. Define deck properties for the exterior (G1) and interior girders (G2) by double-clicking Deck Profile in the tree. Click on Compute from Typical Section button and enter a slab depth of the full depth minus 0.5 inch as shown below. Click OK twice to save to memory and close the window.



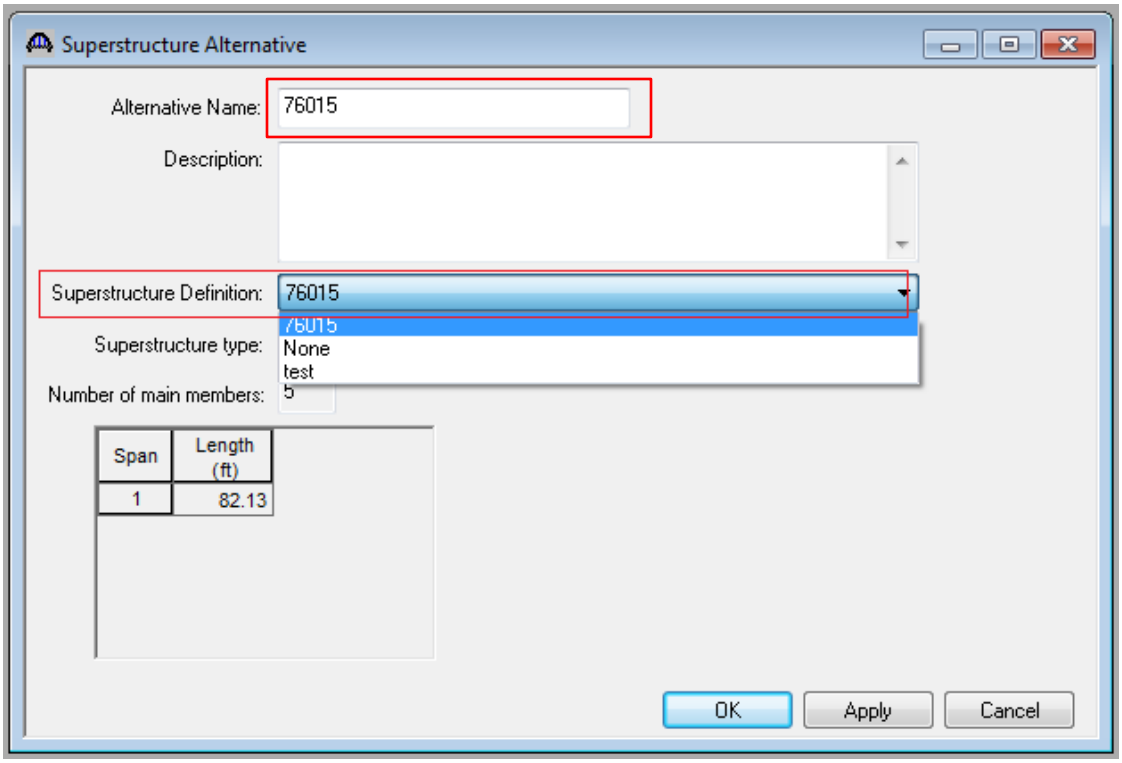
38. From the bridge workspace, double-click on Bridge Alternatives and enter an Alternative Name as shown below. Click OK to save to memory and close the window.



a. Double-click on superstructure folder in the tree and enter a superstructure name as shown below. Click OK to save to memory and close the window.



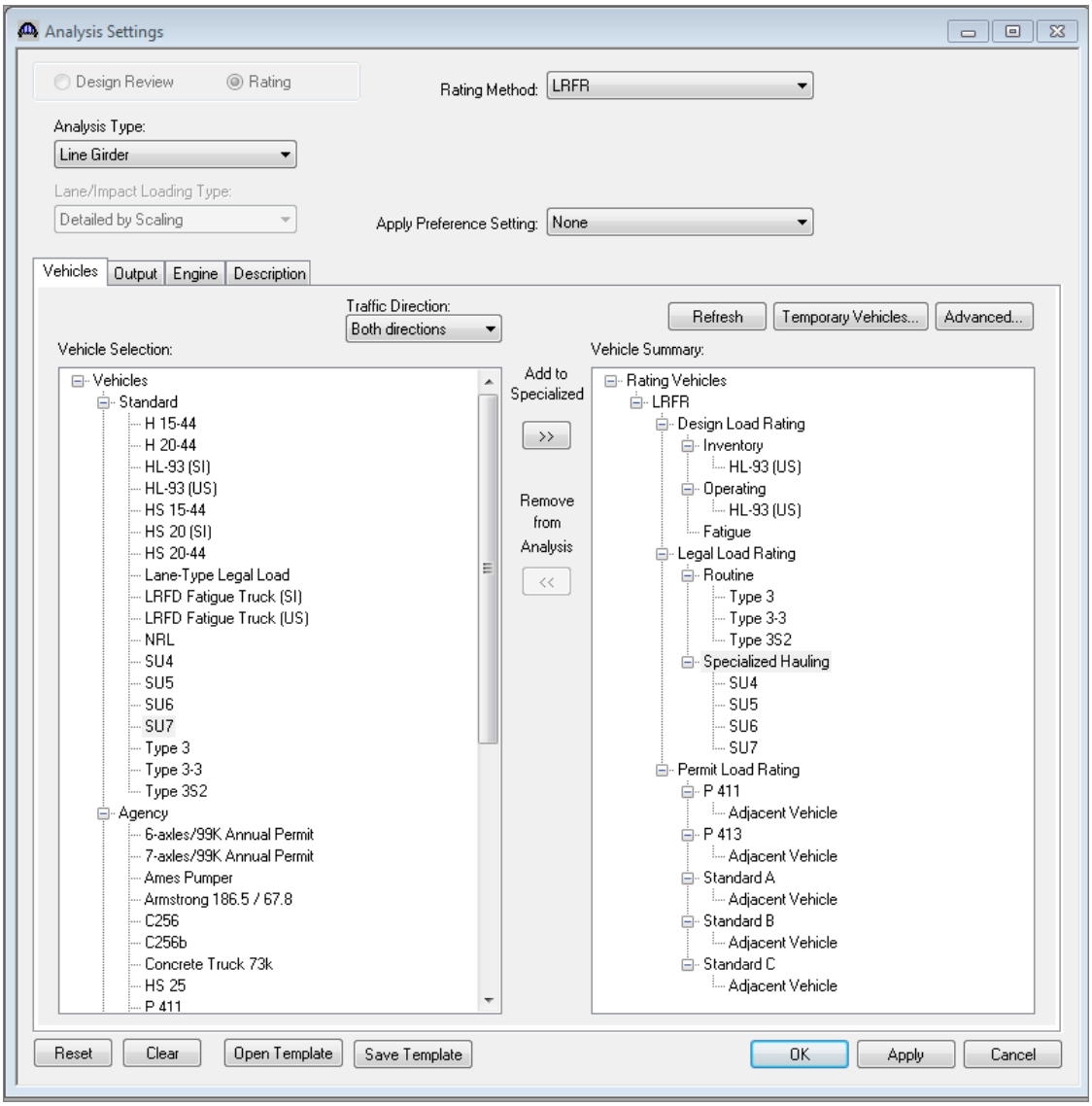
b. Double-click on Superstructure Alternatives folder in the tree. Enter a name and select the bridge that was created earlier under the superstructure definitions as shown below. Click OK to save to memory and close the window.



The AASHTOWare BrR file can now be analyzed.

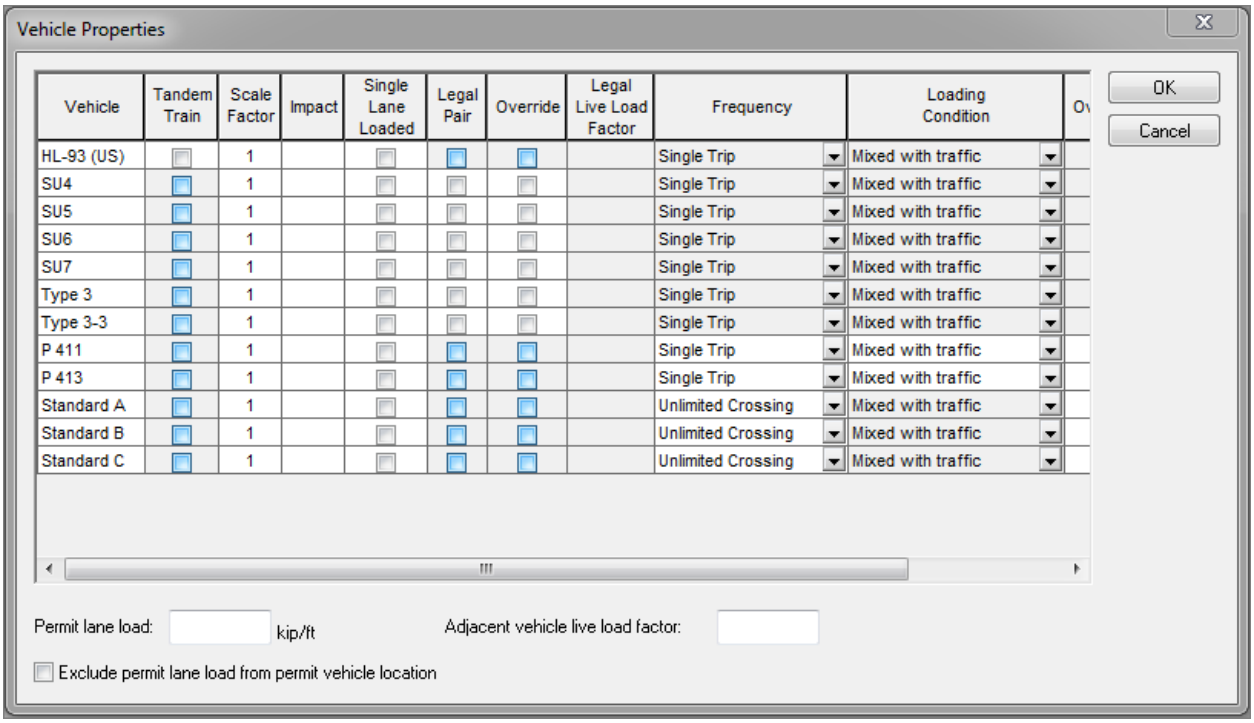
39. To perform LRFR rating, click the Analysis Settings button, , on the toolbar to open the window shown below. Select the following event setting listed below:
    - -Rating Method: LRFR
    - -Analysis Type: Line Girder
    - -Lane/Impact Loading Type: As Requested
    - -Apply Preference Setting: None
    - -Traffic Directions: Both Directions

    a. Add vehicles under the Vehicle Summary. To add vehicles under the Vehicle Summary, first select the Inventory under Design Load Rating. Then under Vehicle Selection select the HL-93 (US) vehicle and click on Add to Operating arrow button. Do the same procedure for the Operating under the Design Load Rating. Repeat the same process to add legal loads and permit vehicles to the Vehicle Summary as shown below.



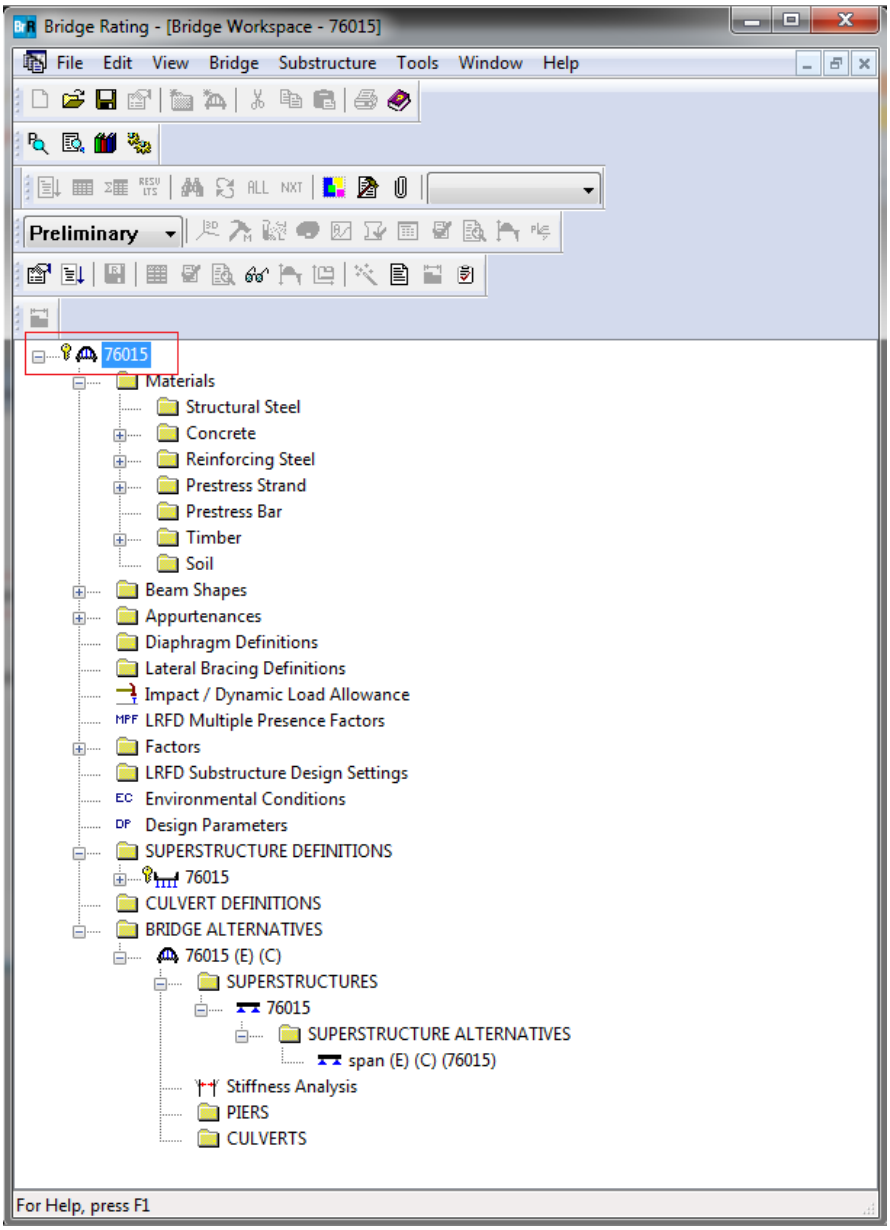
b. Click on the **Advanced** button in the Analysis Settings window to take you to Vehicle Properties window. This window allows you to override vehicle properties entered in the previous windows. The correct Frequencies and Loading Conditions for the legal and permit vehicles are shown below.

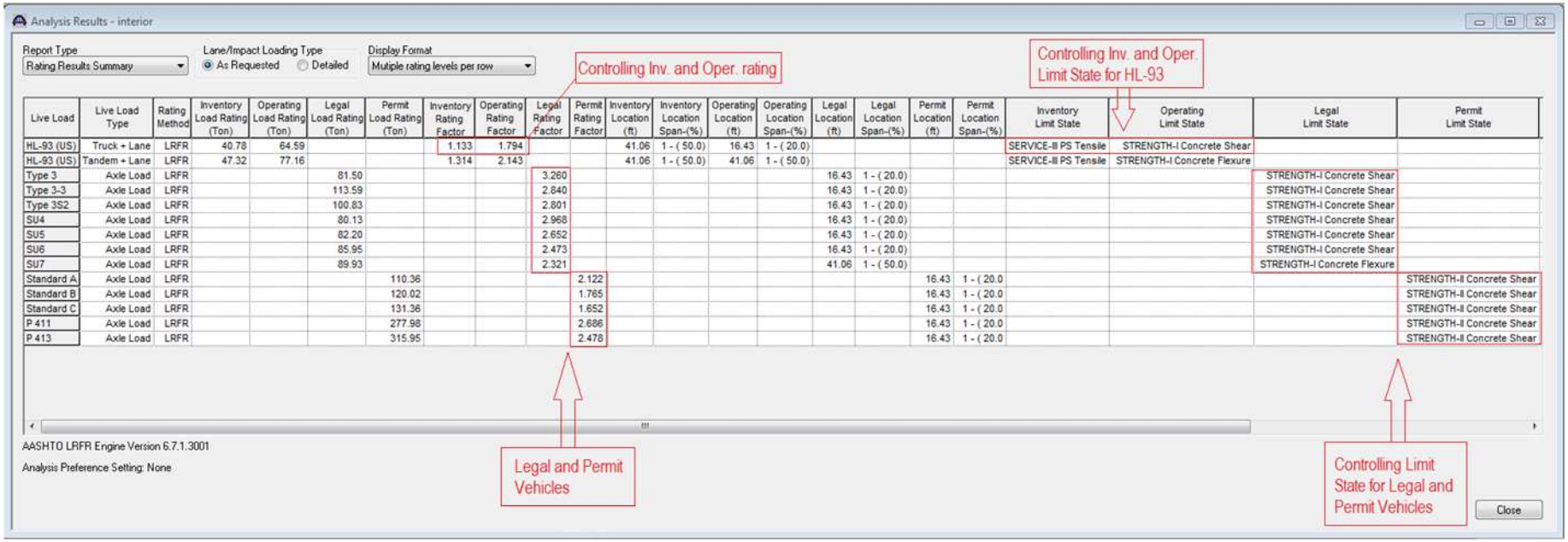
c. To save the setting, click on the **Save Template** button and enter the desired template name and click **Save**. This Template can be used for future load rating analysis.



d. Click OK to save to memory and close the window.

e. Select the bridge in the Bridge Workspace as shown below and click on the Analyze button, on the toolbar to perform the rating. When the rating is finished you can review the results by selecting either the exterior girder (G1) or interior girder (G2) under the Member Alternatives folder in the tree and clicking the View analysis Report icon on the toolbar. The window shown below will open (Load rating results shown are for interior girder only).


Bridge Rating - [Bridge Workspace - 76015]
File Edit View Bridge Substructure Tools Window Help
Preliminary
76015
Materials
Structural Steel
Concrete
Reinforcing Steel
Prestress Strand
Prestress Bar
Timber
Soil
Beam Shapes
Appurtenances
Diaphragm Definitions
Lateral Bracing Definitions
Impact / Dynamic Load Allowance
LRFD Multiple Presence Factors
Factors
LRFD Substructure Design Settings
Environmental Conditions
Design Parameters
SUPERSTRUCTURE DEFINITIONS
76015
CULVERT DEFINITIONS
BRIDGE ALTERNATIVES
76015 (E) (C)
SUPERSTRUCTURES
76015
SUPERSTRUCTURE ALTERNATIVES
span (E) (C) (76015)
Stiffness Analysis
PIERS
CULVERTS
For Help, press F1


Analysis Results - interior
Report Type
Rating Results Summary
Lane/Impact Loading Type
As Requested
Detailed
Display Format
Mutiple rating levels per row
Controlling Inv. and Oper. rating
Controlling Inv. and Oper. Limit State for HL-93
Live Load | Live Load Type | Rating Method | Inventory Load Rating (Ton) | Operating Load Rating (Ton) | Legal Load Rating (Ton) | Permit Load Rating (Ton) | Inventory Rating Factor | Operating Rating Factor | Legal Rating Factor | Permit Rating Factor | Inventory Location (ft) | Inventory Location Span-(%) | Operating Location (ft) | Operating Location Span-(%) | Legal Location (ft) | Legal Location Span-(%) | Permit Location (ft) | Permit Location Span-(%) | Inventory Limit State | Operating Limit State | Legal Limit State | Permit Limit State
HL-93 (US) | Truck + Lane | LRFR | 40.78 | 64.59 | | | 1.133 | 1.794 | | | 41.06 | 1 - (50.0) | 16.43 | 1 - (20.0) | | | | | SERVICE-II PS Tensile | STRENGTH-I Concrete Shear | |
HL-93 (US) | Tandem + Lane | LRFR | 47.32 | 77.16 | | | 1.314 | 2.143 | | | 41.06 | 1 - (50.0) | 41.06 | 1 - (50.0) | | | | | SERVICE-II PS Tensile | STRENGTH-I Concrete Flexure | |
Type 3 | Axle Load | LRFR | | | 81.50 | | | | 3.260 | | | | | | 16.43 | 1 - (20.0) | | | | | STRENGTH-I Concrete Shear |
Type 3-3 | Axle Load | LRFR | | | 113.59 | | | | 2.840 | | | | | 16.43 | 1 - (20.0) | | | | | STRENGTH-I Concrete Shear |
Type 3S2 | Axle Load | LRFR | | | 100.83 | | | | 2.801 | | | | | 16.43 | 1 - (20.0) | | | | | STRENGTH-I Concrete Shear |
SU4 | Axle Load | LRFR | | | 80.13 | | | | 2.968 | | | | | 16.43 | 1 - (20.0) | | | | | STRENGTH-I Concrete Shear |
SU5 | Axle Load | LRFR | | | 82.20 | | | | 2.652 | | | | | 16.43 | 1 - (20.0) | | | | | STRENGTH-I Concrete Shear |
SU6 | Axle Load | LRFR | | | 85.95 | | | | 2.473 | | | | | 16.43 | 1 - (20.0) | | | | | STRENGTH-I Concrete Shear |
SU7 | Axle Load | LRFR | | | 89.93 | | | | 2.321 | | | | | 41.06 | 1 - (50.0) | | | | | STRENGTH-I Concrete Flexure |
Standard A | Axle Load | LRFR | | | | 110.36 | | | | 2.122 | | | | | | 16.43 | 1 - (20.0 | | | | STRENGTH-II Concrete Shear |
Standard B | Axle Load | LRFR | | | | 120.02 | | | | 1.765 | | | | | | 16.43 | 1 - (20.0 | | | | STRENGTH-II Concrete Shear |
Standard C | Axle Load | LRFR | | | | 131.36 | | | | 1.652 | | | | | | 16.43 | 1 - (20.0 | | | | STRENGTH-II Concrete Shear |
P 411 | Axle Load | LRFR | | | | 277.98 | | | | 2.686 | | | | | | 16.43 | 1 - (20.0 | | | | STRENGTH-II Concrete Shear |
P 413 | Axle Load | LRFR | | | | 315.95 | | | | 2.478 | | | | | | 16.43 | 1 - (20.0 | | | | STRENGTH-II Concrete Shear
AASHTO LRFR Engine Version 6.7.1.3001
Analysis Preference Setting: None
Legal and Permit Vehicles
Controlling Limit State for Legal and Permit Vehicles
Close